TECHNICAL MANUAL
WITH CASE HISTORIES
Revised as of August 2014
INTRODUCTION [1 of 4]

CAST STONE is a highly refined architectural precast building stone manufactured to simulate natural cut stone. One of the oldest known types of concrete, it is the most aesthetically refined form of concrete known today. Cast Stone is a masonry product, which provides architectural trim, ornamentation or functional features to buildings and other structures. The earliest known use of Cast Stone was in the year 1138. The product was first used extensively in London in the year 1900 and in America around 1920. The Cast Stone Institute® was incorporated in 1927. Since the early 1920’s, Cast Stone has earned widespread acceptance in the architectural community as a superior replacement for many masonry materials and for all types of natural cut building stone.

Cast Stone is made from fine and coarse aggregates such as limestone, marble, calcite, granite, quartz, natural sands, Portland cement, mineral oxide coloring pigments, chemical admixtures and water. Not surprising, then, Cast Stone is available in any color and can look like limestone, brownstone, bluestone, granite, slate, travertine or marble. It can match terra cotta or brick and makes a perfect substitute for brick shapes.

The raw material mixtures are proportioned for maximum density and to produce the required “fine grained texture similar to natural stone with no bug-holes permitted” dictated by industry standards. White Portland cement (ASTM C 150) is usually used to achieve lighter colors and color consistency. Blending of grey Portland cement and coloring pigments (ASTM C 979) with the white cement to achieve color is a fairly common practice. Sands are naturally available in a wide variety of colors and they can be crushed from quarried stones as well. Reinforcement can be added to provide the structural advantages of precast concrete with the beauty of natural stone.

Since a rich cement/aggregate ratio of 1:3 is normally used, a properly (warm-moist) cured Cast Stone unit will have a higher compressive strength (6,500 psi) and a lower cold water absorption rate (6%) than natural limestone or normal concrete. Testing methods include ASTM C 1194, Standard Test Method for Compressive Strength of Architectural Cast Stone, and ASTM C 1195, Standard Test Method for Absorption of Architectural Cast Stone. These tests are evaluated according to the latest specification (04 70 00-04) published by the Cast Stone Institute®.

Testing for color variation may also be performed according to ASTM D 2244, Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates. Expect color variation to be about equal to a good limestone installation. Freeze-thaw resistance may be tested according to ASTM C 666, Method A; look for less than 5% weight loss after 300 cycles (about 100-125 years of weathering). Specifiers should be aware that C 666 tests can take months (and thousands of dollars) to perform so it is wise to find a manufacturer who has already tested the proposed materials.

Since Cast Stone is a type of architectural precast concrete, the question is often asked: “What is difference between Cast Stone and architectural precast concrete?” The short answer is that Cast Stone is used in place of natural stone. As a type of building stone, Cast Stone is specified under the masonry division 04 70 00-04. It is usually set by a masonry contractor using standard building stone anchors. Perhaps most important, unless otherwise specified, Cast Stone looks like natural, dimensional, cut building stone. Upon close examination, the finish of Cast Stone looks like limestone; some call it a “sugar cube finish” to distinguish its appearance from the “pebbly with voids” appearance which is normally associated with concrete. This dense finish is more resistant to weather and dirt; and the fine aggregates retain the granular texture through decades of exposure to the elements. Sandblast or chemical retardation finishing methods (normally used in finishing of architectural precast concrete panels) are seldom used with Cast Stone because of the dulling of aggregates and the loss of fine detail, which are not acceptable in quality Cast Stone work.
INTRODUCTION [2 of 4]

The manufacture of Cast Stone is the most labor-intensive of all concrete products. Specialized work is usually carried out on a departmental basis consisting of the Drafting/Engineering, Pattern/Mold, Casting/Curing and Finishing/Shipping areas. Workers develop their various skills in both procedure-oriented and craft-oriented ways. The manufacturers have developed procedures that work for the different job functions, but craftsmanship, talent and technique are passed along by the workers; sometimes for generations.

THE PLANNING PHASE
To assure the success of the project, the detailer (draftsperson) assigned to a Cast Stone job must have knowledge of architectural styles and designs as well as experience with the manufacturing techniques and the installation methods. The manufacturer details each piece with an aim toward simplification and standardization. As with any custom product, a great deal of economy is achieved by taking advantage of repetition. Shop drawings should be specified as needed - usually to show details and sizes of stones, arrangement of joints, relationship with adjacent materials and the location of each piece on the structure. Some builders and manufacturers, however, prefer to simply work with “shop tickets” which only show the part to be furnished; leaving jointery and fit up to the people in the field.

Cast Stone can be formed in a greater variety of shapes than other type of natural cut stone. Lengths should be within 15 times the minimum profile thickness whenever possible. Consult your manufacturer if longer lengths are absolutely necessary. Longer lengths invite cracking and handling problems. Try to keep the backside flat and unexposed to view. Remember, most shapes are cast into a mold with four sides and a bottom. One side will always be unformed; typically the bottom of the stone. Never design a piece with a thin projection; one, which has thickness less than twice the length of the projection. Weight is approximately 135 lbs. per cubic foot. To figure weights per lineal foot simply multiply cross section dimensions in inches. For instance, a window sill measuring 6” high x 10” deep = 60 lbs. per lineal foot.

ABOUT MOLDS: STANDARD OR CUSTOM?
The pattern or mold shop is the heart of any Cast Stone producer’s enterprise. This is because of the craftsmanship required. The most successful producers have been in the business for many, many years and are usually able to cultivate talent here which is passed down from generation to generation. Patterns for Cast Stone can be made from almost any material. The most common materials are wood, plaster, fiberglass and rubber. Other materials used are clay, gelatin, gypsum, styrofoam, plastic, concrete and one of the earliest casting mediums, sand. Many advances have been made in rubber, which has provided some very durable polyurethanes and polysulfides suitable for not only casting final products, but for obtaining impressions of existing and historical work as well. The journeyman patternmaker knows which material to select for a given application and exactly how to use it.

Many manufacturers carry a large variety of standard molds, and some have expansive catalogs. Most profile molds are relatively inexpensive to make (provided enough repetition is used) and even the most ornate molds are reusable. In general, over 85% of Cast Stone is produced from new molds but the trend is increasing toward catalog-type availability, especially in the residential and landscape markets.

Considerable cost savings can be achieved by using other types of available ornament as a model for the Cast Stone manufacturer to make a mold from. For instance, a stock wooden Tuscan column is readily available from many sources. By specifying the same dimensions as the “ready-made” column (or, better still, supplying the model to the Cast Stone manufacturer) the task of building a mold may be greatly simplified because the costs of model design and creation will be saved.
INTRODUCTION [3 of 4]

Full-length pieces are often salvaged from the original structure and used as models for molds. Ornamental plaster is an excellent modeling material and there are a number of excellent plaster fabricators available for this purpose. One caution though, be sure the materials are not copyrighted.

THE MANUFACTURING PHASE

Whereas “sand casting” was popular many years ago, only a handful of shops use it today. This method involved ramming sand against a positive (or male) pattern, removing the pattern, and filling the resulting void (female mold) with high slump concrete. Although some of the excess water was drawn into the sand, the result was still a product of uncertain durability. Most of the “sand casters” have evolved to more modern casting methods.

The two most widely used casting methods in use today are the “Vibrant Dry Tamp” (VDT) system and the “Wet Cast” method. Each method requires a meticulously proportioned mix design consisting of carefully graded and washed natural gravel and sands combined with crushed graded stone meeting the latest requirements of ASTM C 33. It is a mistake to specify the manufacturing method since the manufacturer is ultimately responsible for the result.

The VDT production system entails the vibratory ramming of earth-moist, zero-slump concrete against rigid formwork until it is densely compacted and ready for immediate removal from the form. This process enables as many as 100 pieces to be cast from a single mold in an eight-hour day. It is ideally suited to fast-track construction projects because of its production capability and low formwork requirements. The VDT process guarantees total absence of bug-holes and a grained finish which is almost impossible to distinguish from natural stone. The limitation of this process is that it generally requires one flat, unexposed side to the design as “L” shapes and similar shapes are more costly to produce.

The wet cast process for manufacturing Cast Stone is similar to the manufacturing process used for making architectural precast concrete, but produces a finish which is almost impossible to distinguish from natural stone. Mix designs usually have coarse aggregate smaller than 1/2” and are comprised of an abundance of fines which, combined with careful hand and vibratory concrete placement techniques, leaves little or no voids after finishing of exposed surfaces. The wet cast process is more efficient as pieces become larger, less repetitive or impractical to demold immediately.

The final procedure in the manufacture of Cast Stone is the removal of the cement skin from the outer surface. This exposes the fine aggregates, which make up the matrix. The removal of the cement skin assures that the product will undergo minimal color and texture changes because of weathering. Muriatic (hydrochloric) acid etching is the most popular method of finishing Cast Stone, because of the brilliance of the etched aggregates and the ability of the resulting finished surface to remain clean. The use of a siloxane water repellent is a reliable way to keep stone looking new without changing its appearance. When sealers are used, for maximum long-term durability, apply with an overlapping spray method.

Cost per unit depends greatly on specifications and bid documents. On an average, however, Cast Stone costs less than quarried stone. There are several reasons. One is that it is a molded product and requires no further tooling after the initial pattern is made. Each piece of cut stone must be carved individually. Another reason is freight. Usually quarried stone must be hauled over long distances. Most of the limestone in this country is hauled from Indiana. Many stones come from overseas. Brownstone is now typically available from India and Germany. Imported brownstone is beautiful but the cost is a multiplier. Not ten or twenty percent more, but several times more.
INTRODUCTION [4 of 4]

Cast Stone is a highly versatile architectural precast building material that looks like, is usually stronger than, weathers better, has greater color consistency, can be reinforced, and costs less than natural cut stone.

The purpose of the Cast Stone Institute® is to improve the quality of Cast Stone and to disseminate information regarding its use.
STANDARD SPECIFICATION 04 72 00 (2013)  [1 of 6]
Revised and Approved 2/6/2013

This specification provides basic requirements for Cast Stone, a refined architectural concrete building unit manufactured to simulate natural cut stone, used in Division 4 masonry applications. Cast Stone is a masonry product, used as an architectural feature, trim, and ornament or facing for buildings or other structures.

Materials and processes used for manufacturing Cast Stone vary according to the aggregates locally available to the manufacturers and the processes and techniques used by the manufacturers to obtain the desired appearance and physical properties. Of paramount importance in molding Cast Stone is the need to use a properly proportioned mixture of white and/or grey cements, manufactured or natural sands, carefully selected crushed stone or well graded natural gravel and mineral coloring pigments to achieve the desired appearance while maintaining durable physical properties.

Although a variety of casting methods are used, production conforming to this standard will exceed minimum requirements for compressive strength and weathering qualities essential for normal installations as a suitable replacement for natural cut limestone, brownstone, sandstone, bluestone, granite, slate, keystone, travertine and other natural building stones. The specifier should not prescribe the casting method.

It is hoped that this specification may be helpful to the specifiers in understanding the inherent qualities of Cast Stone and its use. For details and samples of finishes available in your project area, contact your nearest Cast Stone Institute® Producer Member.

1. PART 1 - GENERAL

1.1. SECTION INCLUDES - Architectural Cast Stone.
   A. Scope - Cast Stone shown on architectural drawings and as described in this specification.
      1. Manufacturer shall furnish Cast Stone covered by this specification.

1.2. RELATED SECTIONS
   A. Section – 01 33 00 – Submittal Procedures.
   B. Section – 04 05 13 – Masonry Mortaring.
   C. Section – 04 05 16 – Masonry Grouting.
   D. Section – 04 05 19 – Masonry Anchorage and Reinforcing.
   E. Section – 04 20 20 – Unit Masonry.
   F. Section – 07 90 00 – Joint Protection.

1.3. REFERENCES
   A. ACI 318 – Building Code Requirements for Reinforced Concrete.
   C. ASTM A 615/A 615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Reinforced Concrete.
   F. ASTM C 595 - Blended Cement
   G. ASTM C 1157 - Hydraulic Cement
   I. ASTM C 231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   L. ASTM C 426 - Standard Test Method for Linear Shrinkage of Concrete Masonry Units.
N. ASTM C 618 - Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
P. ASTM C 979 - Standard Specification for Coloring Pigments for Integrally Pigmented Concrete.

1.4. DEFINITIONS
A. Cast Stone - a refined architectural concrete building unit manufactured to simulate natural cut stone, used in Division 4 masonry applications.
   1. Dry Cast – manufactured from zero slump concrete.
      a. Vibrant Dry Tamp (VDT) casting method: Vibratory ramming of earth moist, zero-slump concrete against a rigid mold until it is densely compacted.
      b. Machine casting method: Manufactured from earth moist, zero-slump concrete compacted by machinery using vibration and pressure against a mold until it becomes densely consolidated.
   2. Wet Cast – manufactured from measurable slump concrete.
      a. Wet casting method: manufactured from measurable slump concrete and vibrated into a mold until it becomes densely consolidated.
   3. Specifier Note: Slump, manufacturing method, and apparatus shall be selected by the manufacturer and not specified by the purchaser.

1.5. SUBMITTAL PROCEDURES
A. Comply with Section 01 33 00 – Submittal Procedures.
B. Samples: Submit pieces of the Cast Stone that are representative of the general range of finish and color proposed to be furnished for the project.
C. Test results: Submit manufacturers test results of Cast Stone previously made by the manufacturer.
D. Shop Drawings: Submit manufacturers shop drawings including profiles, cross-sections, reinforcement, exposed faces, arrangement of joints (optional for standard or semi-custom installations), anchoring methods, anchors (if required), annotation of stone types and their location.
E. Warranty: Submit Cast Stone Institute® Member Limited Warranty.
F. Certification: Submit valid Cast Stone Institute® Plant Certification.

1.6. QUALITY ASSURANCE
A. Manufacturer Qualifications:
   1. Cast Stone shall be produced in a plant certified by the Cast Stone Institute®.
   2. Manufacturer shall have sufficient plant facilities to produce the shapes, quantities and size of Cast Stone required in accordance with the project schedule.
   3. Manufacturer shall submit a written list of projects similar in scope and at least three (3) years of age, along with owner, architect and contractor references.
B. Standards: Comply with the requirements of the Cast Stone Institute® Technical Manual and the project specifications. Where a conflict may occur, the contract documents shall prevail.
C. Mock-up (Optional): Provide full size unit(s) for use in construction of sample wall. The approved mock-up shall become the standard for appearance and workmanship for the project.

D. Warranty Period: 10 years.

2. PART 2 - PRODUCTS

2.1. ARCHITECTURAL CAST STONE

A. Comply with ASTM C 1364

B. Physical properties: Provide the following:
   1. Compressive Strength - ASTM C 1194: 6,500 psi minimum for products at 28 days.
   2. Absorption - ASTM C 1195: 6% maximum by the cold water method, or 10% maximum by the boiling method for products at 28 days.
   3. Air Content – ASTM C 173 or C 231, for wet cast product shall be 4-8% for units exposed to freeze-thaw environments. Air entrainment is not required for VDT products.
   4. Freeze-thaw – ASTM C 1364: The CPWL shall be less than 5% after 300 cycles of freezing and thawing.
   5. Linear Shrinkage – ASTM C 426: Shrinkage shall not exceed 0.065%.

C. Job site testing – One sample from production units may be selected at random from the field for each 500 cubic feet delivered to the job site.
   1. Three field cut cube specimens from each of these samples shall have an average minimum compressive strength of not less than 85% with no single specimen testing less than 75% of design strength as allowed by ACI 318.
   2. Three field cut cube specimens from each of these samples shall have an average maximum cold-water absorption of 6%.
   3. Field specimens shall be tested in accordance with ASTM C 1194 and C 1195.

2.2. RAW MATERIALS

A. Portland cement – Type I or Type III, white and/or grey, ASTM C 150.
   Blended Cement, ASTM C595 or Hydraulic Cement ASTM C1157

B. Coarse aggregates - Granite, quartz or limestone, ASTM C 33, except for gradation, and are optional for the VDT casting method.

C. Fine aggregates - Manufactured or natural sands, ASTM C 33, except for gradation.

D. Colors - Inorganic iron oxide pigments, ASTM C 979 except that carbon black pigments shall not be used.

E. Admixtures - Comply with the following:
   1. ASTM C 260 for air-entraining admixtures.
   2. ASTM C 494/C 495M Types A - G for water reducing, retarding, accelerating and high range admixtures.
   3. Other admixtures: Integral water repellents and other chemicals, for which no ASTM Standard exists, shall be previously established as suitable for use in concrete by proven field performance or through laboratory testing.
   4. ASTM C 618 mineral admixtures of dark and variable colors shall not be used in surfaces intended to be exposed to view.
   5. ASTM C 989 granulated blast furnace slag may be used to improve physical properties. Tests are required to verify these features.

F. Water – Potable.

G. Reinforcing bars:
   1. ASTM A 615/A 615M: Grade 40 or 60 steel galvanized or epoxy coated when cover is less than 1.5 in.
   2. Welded Wire Fabric: ASTM A 185 where applicable for wet cast units.

H. Fiber reinforcement (optional): ASTM C 1116
I. All anchors, dowels and other anchoring devices and shims shall be standard building stone anchors commercially available in a non-corrosive material such as zinc plated, galvanized steel, brass, or stainless steel Type 302 or 304.

2.3. COLOR AND FINISH
A. Match sample on file in architect’s office.
B. All surfaces intended to be exposed to view shall have a fine-grained texture similar to natural stone, with no air voids in excess of 1/32 in. and the density of such voids shall be less than 3 occurrences per any 1 in.² and not obvious under direct daylight illumination at a 5 ft distance.
C. Units shall exhibit a texture approximately equal to the approved sample when viewed under direct daylight illumination at a 10 ft. distance.
   1. ASTM D 2244 permissible variation in color between units of comparable age subjected to similar weathering exposure.
      a. Total color difference – not greater than 6 units.
      b. Total hue difference – not greater than 2 units.
D. Minor chipping resulting from shipment and delivery shall not be grounds for rejection. Minor chips shall not be obvious under direct daylight illumination from a 20-ft. distance.
E. The occurrence of crazing or efflorescence shall not constitute a cause for rejection.
F. Remove cement film, if required, from exposed surfaces prior to packaging for shipment.

2.4. REINFORCING
A. Reinforce the units as required by the drawings and for safe handling and structural stress.
B. Minimum reinforcing shall be 0.25 percent of the cross section area.
C. Reinforcement shall be noncorrosive where faces exposed to weather are covered with less than 1.5 in. of concrete material. All reinforcement shall have minimum coverage of twice the diameter of the bars.
D. Panels, soffits and similar stones greater than 24 in. in one direction shall be reinforced in that direction. Units less than 24 in. in both their length and width dimension shall be non-reinforced unless otherwise specified.
E. Welded wire fabric reinforcing shall not be used in dry cast products.

2.5. CURING
A. Cure units in a warm curing chamber approximately 100°F (37.8°C) at 95 percent relative humidity for approximately 12 hours, or cure in a 95 percent moist environment at a minimum 70°F (21.1°C) for 16 hours after casting. Additional yard curing at 95 percent relative humidity shall be 350 degree-days (i.e. 7 days @ 50°F (10°C) or 5 days @ 70°F (21°C)) prior to shipping. Form cured units shall be protected from moisture evaporation with curing blankets or curing compounds after casting.

2.6. MANUFACTURING TOLERANCES
A. Cross section dimensions shall not deviate by more than ±1/8 in. from approved dimensions.
B. Length of units shall not deviate by more than length/360 or ±1/8 in., whichever is greater, not to exceed ±1/4 in.
   1. Maximum length of any unit shall not exceed 15 times the average thickness of such unit unless otherwise agreed by the manufacturer.
C. Warp, bow or twist of units shall not exceed length/360 or ±1/8 in., whichever is greater.
D. Location of dowel holes, anchor slots, flashing grooves, false joints and similar features – On formed sides of unit, 1/8 in., on unformed sides of unit, 3/8 in. maximum deviation.

2.7. PRODUCTION QUALITY CONTROL
1. Test compressive strength and absorption from specimens taken from every 500 cubic feet of product produced.
2. Perform tests in accordance ASTM C 1194 and C 1195.
3. Have tests performed by an independent testing laboratory every six months.
4. New and existing mix designs shall be tested for strength and absorption compliance prior to producing units.
5. Retain copies of all test reports for a minimum of two years.

2.8. DELIVERY, STORAGE AND HANDLING
   A. Mark production units with the identification marks as shown on the shop drawings.
   B. Package units and protect them from staining or damage during shipping and storage.
   C. Provide an itemized list of product to support the bill of lading.

3. PART 3 EXECUTION

3.1. EXAMINATION
   A. Installing contractor shall check Cast Stone materials for fit and finish prior to installation. Unacceptable units shall not be set.

3.2. SETTING TOLERANCES
   B. Set stones 1/8 in. or less, within the plane of adjacent units.
   C. Joints, plus - 1/16 in., minus - 1/8 in.

3.3. JOINTING
   A. Joint size:
      1. At stone/brick joints 3/8 in.
      2. At stone/stone joints in vertical position 1/4 in. (3/8 in. optional).
   B. Joint materials:
      1. Mortar, Type N, ASTM C 270.
      2. Use a full bed of mortar at all bed joints.
      3. Flush vertical joints full with mortar.
      4. Leave all joints with exposed tops or under relieving angles open for sealant.
      5. Leave head joints in copings and projecting components open for sealant.
   C. Location of joints:
      1. As shown on shop drawings.
      2. At control and expansion joints unless otherwise shown.

3.4. SETTING
   A. Drench units with clean water prior to setting.
   B. Fill dowel holes and anchor slots completely with mortar or non-shrink grout.
   C. Set units in full bed of mortar, unless otherwise detailed.
   D. Rake mortar joints 3/4 in. in for pointing.
   E. Remove excess mortar from unit faces immediately after setting.
   F. Tuck point unit joints to a slight concave profile.

3.5. JOINT PROTECTION
   A. Comply with requirements of Section 07 90 00.
   B. Prime ends of units, insert properly sized backing rod and install required sealant.

3.6. REPAIR AND CLEANING
   A. Repair chips with touchup materials furnished by manufacturer.
   B. Saturate units to be cleaned prior to applying an approved masonry cleaner.
   C. Consult with manufacturer for appropriate cleaners.
3.7. INSPECTION AND ACCEPTANCE
   A. Inspect finished installation according to Cast Stone Institute® Technical Bulletin #36.
   B. Do not field apply water repellent until repair, cleaning, inspection and acceptance is completed.

3.8 WATER REPELLENT (Optional)
   A. Apply water repellent in accordance with Cast Stone Institute® Technical Bulletin #35 or water repellent manufacturer’s directions.
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Although a variety of casting methods are used, production conforming to this standard will exceed minimum requirements for compressive strength and weathering qualities essential for normal installations as a suitable replacement for natural cut limestone, brownstone, sandstone, bluestone, granite, slate, keystone, travertine and other natural building stones. The specifier should not prescribe the casting method.

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   F. ASTM C 595 - Blended Cement
   G. ASTM C 1157 - Hydraulic Cement
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   b. Machine casting method: Manufactured from earth moist, zero-slump concrete compacted by machinery using vibration and pressure against a mold until it becomes densely consolidated.

2. Wet Cast – manufactured from measurable slump concrete.
   a. Wet casting method: manufactured from measurable slump concrete and vibrated into a mold until it becomes densely consolidated.

3. Specifier Note: Selection of manufacturing method (wet cast, dry cast, machine made) and apparatus shall be made by the manufacturer and not by the purchaser.

1.5. SUBMITTAL PROCEDURES

A. Comply with Section 01 33 00 – Submittal Procedures.

B. Samples: Submit pieces of the Cast Stone that are representative of the general range of finish and color proposed to be furnished for the project.

C. Test results: Submit manufacturers test results of Cast Stone previously made by the manufacturer.

D. Shop Drawings: Submit manufacturers shop drawings including profiles, cross-sections, reinforcement, exposed faces, arrangement of joints (optional for standard or semi-custom installations), anchoring methods, anchors (if required), annotation of stone types and their location.

E. Warranty: Submit Cast Stone Institute® Member Limited Warranty.

F. Certification: Submit valid Cast Stone Institute® Plant Certification.

1.6. QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Cast Stone shall be produced in a plant certified by the Cast Stone Institute®.
   2. Manufacturer shall have sufficient plant facilities to produce the shapes, quantities and size of Cast Stone required in accordance with the project schedule.
   3. Manufacturer shall submit a written list of projects similar in scope and at least three (3) years of age, along with owner, architect and contractor references.

B. Standards: Comply with the requirements of the Cast Stone Institute® Technical Manual and the project specifications. Where a conflict may occur, the contract documents shall prevail.
C. Mock-up (Optional): Provide full size unit(s) for use in construction of sample wall. The approved mock-up shall become the standard for appearance and workmanship for the project.

D. Warranty Period: 10 years.

2. PART 2 - PRODUCTS

2.1. ARCHITECTURAL CAST STONE
A. Comply with ASTM C 1364
B. Physical properties: Provide the following:
   1. Compressive Strength - ASTM C 1194: 6,500 psi minimum for products at 28 days.
   2. Absorption - ASTM C 1195: 6% maximum by the cold water method, or 10% maximum by
      the boiling method for products at 28 days.
   3. Air Content – ASTM C 173 or C 231, for wet cast product shall be 4-8% for units exposed to
      freeze-thaw environments. Air entrainment is not required for VDT products.
   4. Freeze-thaw – ASTM C 1364: The CPWL shall be less than 5% after 300 cycles of freezing
      and thawing.
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C. Job site testing – One sample from production units may be selected at random from the field for each
   500 cubic feet delivered to the job site.
   1. Three field cut cube specimens from each of these samples shall have an average minimum
      compressive strength of not less than 85% with no single specimen testing less than 75%
      of design strength as allowed by ACI 318.
   2. Three field cut cube specimens from each of these samples shall have an average maximum
      cold-water absorption of 6%.
   3. Field specimens shall be tested in accordance with ASTM C 1194 and C 1195.

2.2. RAW MATERIALS
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   Blended Cement, ASTM C595 or Hydraulic Cement ASTM C1157
B. Coarse aggregates - Granite, quartz or limestone, ASTM C 33, except for gradation, and are optional
   for the VDT casting method.
C. Fine aggregates - Manufactured or natural sands, ASTM C 33, except for gradation.
D. Colors - Inorganic iron oxide pigments, ASTM C 979 except that carbon black pigments shall not be
   used.
E. Admixtures - Comply with the following:
   1. ASTM C 260 for air-entraining admixtures.
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      accelerating and high range admixtures.
   3. Other admixtures: Integral water repellents and other chemicals, for which no ASTM Standard
      exists, shall be previously established as suitable for use in concrete by proven field
      performance or through laboratory testing.
   4. ASTM C 618 mineral admixtures of dark and variable colors shall not be used in surfaces
      intended to be exposed to view.
   5. ASTM C 989 granulated blast furnace slag may be used to improve physical properties. Tests
      are required to verify these features.
F. Water – Potable.
G. Reinforcing bars:
   1. ASTM A 615/A 615M: Grade 40 or 60 steel galvanized or epoxy coated when cover is less
      than 1.5 in.
   2. Welded Wire Fabric: ASTM A 185 where applicable for wet cast units.
H. Fiber reinforcement (optional): ASTM C 1116
I. All anchors, dowels and other anchoring devices and shims shall be standard building stone anchors commercially available in a non-corrosive material such as zinc plated, galvanized steel, brass, or stainless steel Type 302 or 304.

2.3. COLOR AND FINISH
A. Match sample on file in architect’s office.
B. All surfaces intended to be exposed to view shall have a fine-grained texture similar to natural stone, with no air voids in excess of 1/32 in. and the density of such voids shall be less than 3 occurrences per any 1 in.² and not obvious under direct daylight illumination at a 5 ft distance.
C. Units shall exhibit a texture approximately equal to the approved sample when viewed under direct daylight illumination at a 10 ft. distance.
   1. ASTM D 2244 permissible variation in color between units of comparable age subjected to similar weathering exposure.
      a. Total color difference – not greater than 6 units.
      b. Total hue difference – not greater than 2 units.
D. Minor chipping resulting from shipment and delivery shall not be grounds for rejection. Minor chips shall not be obvious under direct daylight illumination from a 20-ft. distance.
E. The occurrence of crazing or efflorescence shall not constitute a cause for rejection.
F. Remove cement film, if required, from exposed surfaces prior to packaging for shipment.

2.4. REINFORCING
A. Reinforce the units as required by the drawings and for safe handling and structural stress.
B. Minimum reinforcing shall be 0.25 percent of the cross section area.
C. Reinforcement shall be noncorrosive where faces exposed to weather are covered with less than 1.5 in. of concrete material. All reinforcement shall have minimum coverage of twice the diameter of the bars.
D. Panels, soffits and similar stones greater than 24 in. in one direction shall be reinforced in that direction. Units less than 24 in. in both their length and width dimension shall be non-reinforced unless otherwise specified.
E. Welded wire fabric reinforcing shall not be used in dry cast products.

2.5. CURING
A. Cure units in a warm curing chamber approximately 100°F (37.8°C) at 95 percent relative humidity for approximately 12 hours, or cure in a 95 percent moist environment at a minimum 70°F (21.1°C) for 16 hours after casting. Additional yard curing at 95 percent relative humidity shall be 350 degree-days (i.e. 7 days @ 50°F (10°C) or 5 days @ 70°F (21°C)) prior to shipping. Form cured units shall be protected from moisture evaporation with curing blankets or curing compounds after casting.

2.6. MANUFACTURING TOLERANCES
A. Cross section dimensions shall not deviate by more than ±1/8 in. from approved dimensions.
B. Length of units shall not deviate by more than length/360 or ±1/8 in., whichever is greater, not to exceed ±1/4 in.
   1. Maximum length of any unit shall not exceed 15 times the average thickness of such unit unless otherwise agreed by the manufacturer.
C. Warp, bow or twist of units shall not exceed length/360 or ±1/8 in., whichever is greater.
D. Location of dowel holes, anchor slots, flashing grooves, false joints and similar features – On formed sides of unit, 1/8 in., on unformed sides of unit, 3/8 in. maximum deviation.

2.7. PRODUCTION QUALITY CONTROL
1. Test compressive strength and absorption from specimens taken from every 500 cubic feet of product produced.
2. Perform tests in accordance ASTM C 1194 and C 1195.
3. Have tests performed by an independent testing laboratory every six months.
4. New and existing mix designs shall be tested for strength and absorption compliance prior to producing units.
5. Retain copies of all test reports for a minimum of two years.

2.8. DELIVERY, STORAGE AND HANDLING
A. Mark production units with the identification marks as shown on the shop drawings.
B. Package units and protect them from staining or damage during shipping and storage.
C. Provide an itemized list of product to support the bill of lading.

3. PART 3 EXECUTION

3.1. EXAMINATION
A. Installing contractor shall check Cast Stone materials for fit and finish prior to installation. Unacceptable units shall not be set.

3.2. SETTING TOLERANCES
B. Set stones 1/8 in. or less, within the plane of adjacent units.
C. Joints, plus - 1/16 in., minus - 1/8 in.

3.3. JOINTING
A. Joint size:
   1. At stone/brick joints 3/8 in.
   2. At stone/stone joints in vertical position 1/4 in. (3/8 in. optional).
B. Joint materials:
   1. Mortar, Type N, ASTM C 270.
   2. Use a full bed of mortar at all bed joints.
   3. Flush vertical joints full with mortar.
   4. Leave all joints with exposed tops or under relieving angles open for sealant.
   5. Leave head joints in copings and projecting components open for sealant.
C. Location of joints:
   1. As shown on shop drawings.
   2. At control and expansion joints unless otherwise shown.

3.4. SETTING
A. Drench units with clean water prior to setting.
B. Fill dowel holes and anchor slots completely with mortar or non-shrink grout.
C. Set units in full bed of mortar, unless otherwise detailed.
D. Rake mortar joints 3/4 in. in for pointing.
E. Remove excess mortar from unit faces immediately after setting.
F. Tuck point unit joints to a slight concave profile.

3.5. JOINT PROTECTION
A. Comply with requirements of Section 07 90 00.
B. Prime ends of units, insert properly sized backing rod and install required sealant.

3.6. REPAIR AND CLEANING
A. Repair chips with touchup materials furnished by manufacturer.
B. Saturate units to be cleaned prior to applying an approved masonry cleaner.
C. Consult with manufacturer for appropriate cleaners.
3.7. INSPECTION AND ACCEPTANCE
   A. Inspect finished installation according to Cast Stone Institute® Technical Bulletin #36.
   B. Do not field apply water repellent until repair, cleaning, inspection and acceptance is completed.

3.8 WATER REPELLENT (Optional)
   A. Apply water repellent in accordance with Cast Stone Institute® Technical Bulletin #35 or water repellent manufacturer’s directions.
DESIGN TIPS – TECHNICAL BULLETIN #50

AIR ENTRAINMENT REQUIREMENTS

In many project specifications today, air entrainment is specified for Cast Stone mixtures when it is only required for units manufactured from wet-cast slump concrete. It is not necessary to add air entrainment additives to units manufactured from zero slump mixes. Accordingly, ASTM C 1364 Standard Specification for Architectural Cast Stone only requires mixtures to contain air entrainment additives for units manufactured from slump concrete mixes.

In order to maintain a durable Cast Stone product, which is subjected to freezing and thawing cycles, it is important to understand what makes the product deteriorate. In the late 1930’s, air-entraining agents were recommended for wet (slump) concrete to increase their durability. The air-entraining agents stabilize billions of microscopic spheres in the cement paste that surround the concrete aggregates. These microscopic spheres allowed absorbed water to expand in the spheres during the freezing cycle. Liquid water expands approximately 9% when it freezes. These spheres provided for built-up internal pressure of the freezing water to be released. Without these air spheres the internal pressure would cause the cement paste to rupture and fail. With repeated freeze-thaw cycles the cement paste will continue to deteriorate and cause severe spalling of the concrete. Cast Stone made with slump concrete requires air entrainment in order to minimize freeze-thaw deterioration.

Air-entraining admixtures in dry tamped Cast Stone mixes have not proven to increase the freeze-thaw durability. Petrographic analysis of Cast Stone made with air-entraining admixtures have shown that the microscopic spheres are not uniformly spaced throughout the mix like wet concrete, but have been condensed into pockets during the tamping process. Integral water repelling admixtures, however, have resulted in an improved durability factor over Cast Stone without admixtures. Tests conducted on dry tamped units manufactured in accordance with ASTM C 1364 with air-entraining agents did not show improved freeze-thaw results.

Unlike wet concrete mixes, dry tamped Cast Stone mixes do not develop a water rich paste to surround the aggregates. Excess water in dry mixes is undesirable because the mix becomes more plastic and tends to slump. Aggregates in dry tamped Cast Stone do not float in a wet paste; they are compacted to such a degree that there is point-to-point contact of the particles. The aggregate particles are coated with a thin cement film to provide bonding and strength with a minimum amount of shrinkage.

Vibrant Dry Tamped Cast Stone (VDT) is manufactured using earth moist mixes having a minimum amount of water in the mixture. This low water content and the tamping process reduces the amount of capillary pores in the VDT thereby minimizing the amount of water that can penetrate into the concrete and potentially cause freeze thaw stresses. Therefore, VDT Cast Stone has an appropriate pore structure, which will accommodate the hydraulic pressure necessary to prevent distress during freezing and thawing cycles. The high strength and low water absorption of VDT cast stone provides a durable building material that can withstand the most severe climates. It is, therefore, frost resistant, provided the degree of water absorption does not exceed a critical amount.

In order to insure freeze-thaw durability, the Cast Stone Institute® and ASTM Specifications require that both wet and dry cast products have a maximum 5% weight loss when subjected to 300 rapid freeze-thaw cycles as prescribed by ASTM C 1364. 300 freeze-thaw cycles is approximately equal to 100 years of natural weathering in the Northern hemisphere climate. This criterion for Cast Stone exceeds other similar types of building products being used today.

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Specification Number</th>
<th>ASTM C 1194</th>
<th>Air Content Range (Cast Stone Institute® Spec 04 70 00-04)</th>
<th>ASTM C 1195</th>
<th>ASTM C 666</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Stone (Dry)</td>
<td>ASTM C 1364</td>
<td>6,500 psi min.</td>
<td>N/A</td>
<td>6% max absorption cycles</td>
<td>5% maximum loss @ 300 freeze-thaw</td>
</tr>
<tr>
<td>Cast Stone (Wet)</td>
<td>ASTM C 1364</td>
<td>6,500 psi min.</td>
<td>4% - 8%</td>
<td>6% max absorption cycles</td>
<td>5% maximum loss @ 300 freeze-thaw</td>
</tr>
</tbody>
</table>
ALLOWING FOR MOVEMENT OF MASONRY MATERIALS

Building materials may experience dimensional changes and movement due to environmental conditions, such as temperature and moisture, or movement of adjacent building elements. If this movement is restrained, cracking may result. By accounting for movement in the wall design, cracking can be controlled. Movement joints are used to control and minimize cracking. There are two types of movement joints typically used in masonry construction; control joints and expansion joints.

Control joints are placed in concrete masonry walls to limit cracks due to shrinkage. Control joints are unbonded vertical separations built into a concrete masonry wall to reduce restraint and permit longitudinal movement. They are located where cracking is likely to occur due to excessive tensile stress. An expansion joint is typically used in brick masonry walls to provide means for expansion and contraction movements produced by temperature changes, loadings or other forces. Expansion joints allow for both expansion and contraction and may be vertical or horizontal.

CAUSES OF MOVEMENT

Temperature Changes
Most building materials experience reversible movements due to temperature change. Concrete masonry movement has been shown to be linearly proportional to temperature change. The coefficient of thermal movement normally used in design is 0.0000045 in./in./°F (0.0000081 mm/mm/°C). Actual values may range from 0.0000025 to 0.0000055 in./in./°F (0.0000045 to 0.0000099 mm/mm/°C) depending mainly on the type of aggregate used in the unit according to the National Concrete Masonry Association. These values are also appropriate for Cast Stone. The actual change in temperature is, of course, determined by geographical location, wall exposure, and color.

Overall, the amount of movement due to temperature change in a cast stonewall is relatively small. For example, a wall constructed during 70°F (21°C) weather and subjected to a minimum temperature of 0°F (-18°C) results in a shortening of about 0.38 in. (9.7 mm) in a 100 foot (30.48 m) long wall using the 0.0000045in./in./°F (0.0000081 mm/mm/°C) coefficient.

MOISTURE MOVEMENTS
Many building materials tend to expand with an increase in moisture content and contract with a loss of water, including concrete and concrete masonry units. However, clay brick units experience irreversible expansion slowly over time upon exposure to water or humid air.

DRYING SHRINKAGE
Drying shrinkage is also due to a change in moisture content. However, drying shrinkage results from the natural moisture loss that results as concrete products are aged, rather than atmospheric moisture changes. Concrete products are composed of a matrix of aggregate particles coated by cement that bonds them together. The amount of cement content influences the amount of drying shrinkage that occurs.

Although mortar is also a cementitious product and does experience drying shrinkage, unit shrinkage has been shown to be the predominate indicator of the overall wall shrinkage principally due to the fact that it represents the largest portion of the wall. Therefore, the shrinkage properties of the unit alone are typically used to establish design criteria for crack control.

Maximum Linear Shrinkage Requirements for Cast Stone is specified in ASTM C 1363 Section 5.7 Linear Shrinkage shall not exceed 0.065% when tested in accordance ASTM C 426.
CAST STONE UNITS
Because shrinkage is expressed as a percentage, individual Cast Stone elements will experience actual shrinkage depending upon their length. In the case of differential movements, hairline cracking is likely to occur when units are designed too long.

Visible cracks exceeding 0.005 in. (1/200 in.) are regarded as deficiencies in high quality Cast Stone installations. This is a much higher standard than is found in architectural concrete work. This has structural implications, as the structural stress limit of Cast Stone must be less than the modulus of rupture for the material to avoid any occurrence of cracking.

When considering non-structural pieces that do not carry any loads other than their own self-weight and transfer wind loads, limiting the length of the Cast Stone members can reduce the potential of cracking. A general rule of limiting the length of a Cast Stone trim element to no more than 15 times the least cross-sectional dimension should be observed in most applications. However, in many cases shorter lengths may be advised. For example, bearing conditions, high wind loads, large lengths of banding and unusual shapes are all factors that affect the structural stress and cracking potential, but vary from job to job.

Temperature and moisture changes can cause changes in the size of Cast Stone elements. Increases in temperature can cause Cast Stone pieces to elongate. Decreases in temperature can have the opposite effect. Similarly, changes in the moisture content of the Cast Stone will affect its size. The magnitude of these physical properties depends in part upon the size of the member. The combined effects of thermal and moisture movements in Cast Stone elements and panels are often negligible. However, Cast Stone units 8 ft. or more in length in any direction may experience up to 1/8 in. or more in expansion or contraction due to combined thermal and moisture movements.

CLAY PRODUCTS
As discussed previously, clay brick units expand irreversibly over time upon exposure to water or humid air. A brick unit is smallest in size when it cools after coming from the kiln. The unit will increase in size due to moisture expansion from that time. Most of the expansion takes place quickly over the first few weeks, but expansion will continue at a much lower rate for several years. According to the Brick Industry Association, the moisture expansion behavior of brick depends primarily on the raw materials and secondarily on the firing temperatures. Brick made from the same raw materials that are fired at lower temperatures will expand more than those fired at higher temperatures.

RECOMMENDATIONS
Cast Stone units laid in mortar should follow the same recommendations for other masonry units. The location of control joints in walls with Cast Stone will depend on the materials used in the entire wall. When Cast Stone is used as an isolated accent in clay brick walls, recommendations for expansion joints for clay brick should be followed. For isolated accent pieces, no other special requirements apply. When Cast Stone banding is used in clay brick walls, the spacing of vertical expansion joints for clay brick and the spacing of control joints for concrete masonry should both be examined. The expansion joint spacing should be based on the most stringent requirement. In addition, the Brick Industry Association recommends providing a bond break between the clay brick and concrete or Cast Stone banding to accommodate the differential movement that will occur. In this case, flashing is often placed either directly above or below the banding course. Using a bond break both above and below the banding course is not recommended unless proper mortar embedment of the anchors in the veneer can be achieved.
ALLOWING FOR MOVEMENT OF MASONRY MATERIALS [3 of 3]

Generally, the recommendations for concrete masonry seem appropriate for Cast Stone. Hairline cracks along mortar bed joints are not unusual in concrete masonry as both the mortar and the masonry units experience shrinkage, nor do they affect the integrity of the wall if properly designed. They can be minimized by keeping lengths of Cast Stone units to within the limits dictated by principles of masonry construction. Large cracks can be avoided by incorporating control joints and other recommended details. Cast Stone units that are to be wetted before installation must be wetted to achieve proper bond with the mortar and avoid cracking.

For Cast Stone units with linear dry shrinkage values up to 0.065% ±,

- Place control joints or expansion joints in veneer walls at a maximum spacing of 25 ft.
- Limit the aspect ratio (L/h) of the wall to 1.5 so that the length of the wall between control or expansion joints is no more than 1.5 times the height of the wall.
- Refrain from installing units until they have been cured to Cast Stone Institute specifications.
- Limit the maximum dimension of any Cast Stone piece to less than 8 ft. unless care is given to accommodate the possible expansion and contraction of the stone.
BASIC COMPARISONS BETWEEN VARIOUS MASONRY MATERIALS

Cast Stone is a time-tested alternative to natural cut stone and has been in existence for hundreds of years. Through the product’s history, technical and performance standards have been established to assure long-term durability and resistance to freeze-thaw, water absorption, abrasion and dirt. United States Cast Stone standards are designed to provide a product of “infinite life” which, in concrete terminology, means exceeding 100 years. Since other concrete and simulated stone products are available for use in construction, architects or other specifiers who are looking for such durable physical attributes should be sure to specify a product that meets established codes and specifications for that level of performance. Most other simulated stone, ordinary concrete and stone look-alike materials cannot meet the minimum physical requirements established as Cast Stone standards. The in-service impact of look-alike materials and their inability to meet rigorous endurance performance criteria are other issues that should be taken into account by designers when comparing the alternative materials and, are discussed below.

Basic Material and Standards Comparisons
- Cast Stone is an architectural concrete building stone product. It combines the strength and durability of reinforced precast concrete with the appearance of natural stone. It consists of Portland cement, fine and coarse aggregates usually of granite, quartz or limestone, natural or manufactured sands and high performance chemical admixtures. Many ASTM Standards exist for Cast Stone and all of the raw materials it comprises. Additional standards for design, performance, sampling and testing of Cast Stone concrete products are published by AIA, CSI, ACI, APA, PCI and UKCSA.

- Of prime importance in selecting an enduring masonry product to be used as an architectural trim, feature or ornament for buildings and other structures should be the following, as measured by an ASTM Standard Test Method specifically designated for the particular product:
  - Relative high compressive strength
  - Relative low absorption
  - Enduring freeze thaw resistance
  - Inclusion of steel reinforcement to provide tensile and or flexure strength

PERFORMANCE CHARACTERISTICS
All concrete products are not equal! The Cast Stone Institute® strives to maintain some of the highest quality concrete produced for the Architectural community. With our quality control program and the high production standards, we believe that our products exceed most architectural requirements for building components. The chart below points out the physical features as compared to other types of building products.

PHYSICAL PROPERTIES COMPARISON CHART

<table>
<thead>
<tr>
<th>Product Type</th>
<th>*Number</th>
<th>PSI Minimum</th>
<th>Air Content Range (Cast Stone Institute® Spec 04 70 00-04)</th>
<th>Absorption Maximum</th>
<th>Freeze-thaw Maximum Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Stone (Dry)</td>
<td>ASTM C 1364</td>
<td>6,500</td>
<td>NA</td>
<td>6%</td>
<td>5% @ 300 cycles</td>
</tr>
<tr>
<td>Cast Stone (Wet)</td>
<td>ASTM C 1364</td>
<td>6,500</td>
<td>4%-8%</td>
<td>6%</td>
<td>5% @ 300 cycles</td>
</tr>
<tr>
<td>Architectural Precast</td>
<td>CST 03450</td>
<td>5,000</td>
<td>4%-6%</td>
<td>6%</td>
<td>NOT REQUIRED</td>
</tr>
<tr>
<td>Limestone Dimension Stone</td>
<td>ASTM C 568</td>
<td>Grade II 4,000</td>
<td>NA</td>
<td>7.5%</td>
<td>NOT REQUIRED</td>
</tr>
<tr>
<td>Calcium Silicate Brick (Sand-Lime Brick)</td>
<td>ASTM C 73-99a</td>
<td>Grade: MW 3,500 SW 5,500</td>
<td>NA</td>
<td>18%</td>
<td>15%</td>
</tr>
</tbody>
</table>

* Not all compared products have ASTM requirements.
CARE & MAINTENANCE - TECHNICAL BULLETIN #39

CLEANING

During construction, prevention against staining is mandatory and becomes the best solution for a clean finished project. Every effort should be taken to protect the Cast Stone during storage, setting, and after installation. Storage of Cast Stone should be above ground on non-staining planks or pallets. The storage site should be away from heavy construction traffic. Cast Stone stored for an extended period of time should be kept on pallets or non-staining planking and covered with non-staining tarpaulins. After setting, columns, pilasters, entry jambs, windowsills and all stone with projecting profiles should be protected with non-staining materials during the remaining construction.

Regardless of the degree of care exercised during construction, a final washdown will be needed and, normally, whatever is specified to clean the brickwork will adequately clean the Cast Stone. A variety of commercial cleaners are available made specifically to remove a stain or type of soil without altering the finish or causing damage to the stone. Most contain detergents combined with mild solutions of phosphoric and/or muriatic acids. Use only the commercial cleaner developed for the specific stain to be removed. Extreme care should be taken when applying acidic cleaners to areas where joints are left open or where sealant is used as jointing material. The sealant manufacturer should be contacted to ascertain compatibility with cleaning materials. Acids left behind the stone on masonry wythe may cause corrosion problems later.

The most common stains due to construction are dirt and mortar. Dirt can be removed by scrubbing with a mild detergent and water. Mortar stains require removing excess mortar, care taken not to scar the stone followed by the brushing of a solution with a commercial cleaner designed specifically to remove mortar. Consult the brick supplier prior to applying acids to trim items. Insure that lower stone courses are frequently drenched with water because as acid is rinsed down the wall it can gather strength when reapplied. Take necessary steps to protect windows, door and grade materials.

When unusual stains are encountered, the same procedures, which are recommended to clean concrete, will normally clean Cast Stone. The Portland Cement Association publishes a guide for the removal of stains in concrete. The most important step to stain removal is identifying the stain and its cause. There are degreasers and paint removers readily available. Any treatment should be tested on a small inconspicuous area prior to cleaning the main units.

Dunnage materials used in the packing and transport of Cast Stone can leave stains (or clean spots) after becoming wet. Wood packaging products can transfer resins to the surface, which may be easily removed. However, solid dunnage made from fresh timber can cause dunnage marks, which become difficult to remove. Packing and dunnage materials should always allow the exposed surfaces to breathe, especially when stones are palletized or placed into storage shortly after manufacture. This will avoid color differential due to moisture becoming trapped on the surface of the stone.

Power washing and sandblasting are not recommended procedures for cleaning Cast Stone. Metal fiber brushes, rubbing stones and any tool or device that can scar the stone are not to be used for cleaning Cast Stone.
DESIGN TIPS – TECHNICAL BULLETIN #41
COLD WEATHER SETTING PRACTICES

Never set Cast Stone on a frozen or ice covered wall. All masonry bond will be ineffectual. Cold weather building practices have been developed to protect masonry against the perils of freezing when construction must be carried on in such environments.

Avoid setting stone with mortar in extreme cold. Stonework set in cold (below 40 degree) weather may expand and crack mortar bond in warm temperatures. Calcium chloride will cause efflorescence. See Technical Bulletin #33 on Efflorescence. Mixing water may be heated up to 160 degrees to heat the mortar to between 40F and 120F. Sands may be heated with propane or air blast heaters. All materials must be heated slowly to prevent scorching.

The International Masonry Industry All Weather Council recommends the following:

- Above 40°F: Normal masonry procedure. Cover walls at end of workday to prevent water entering masonry.
- 40°F - 32°F: Heat mixing water to produce mortar temperatures between 40°F - 120°F. Cover walls with plastic or canvas to prevent wetting and freezing.
- 32°F - 25°F: Heat mixing water and sand to produce mortar temperatures between 40°F - 120°F. Cover walls with plastic or canvas to prevent wetting and freezing.
- 25°F - 20°F: Heating mixing water and sand to produce mortar temperatures between 40°F - 120°F. Cover walls with plastic or canvas to prevent wetting and freezing. Mortar on boards should be maintained above 40°F. Cover walls and materials at the end of the day to prevent wetting and freezing. Maintain masonry above freezing for 16 hours using auxiliary heat or insulated blankets.
- 20°F - 0°F: Heat mixing water and sand to produce mortar temperatures between 40°F - 120°F. Cover walls with plastic or canvas to prevent wetting or freezing. Mortar on boards should be maintained above 40°F. Cover walls and materials at the end of the day to prevent wetting and freezing. Provide enclosures and supply sufficient heat to maintain masonry enclosure above 32°F for 24 hours.

Touch up and repair should not be done in any environment which may be subject to freezing within 72 hours without conditioning of the stone or the repair environment.

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
CRAZING

Crazing is defined as fine and random cracking extending only through the surface. It can appear along or perpendicular to the length, in polygonal shapes or as random “map cracking.” Crazing is due to differential contraction between the surface and interior sections and many different views have been made as to the cause and elimination of crazing. Crazing has no structural or durability significance and does not by itself constitute a cause for rejection, according to ASTM C 1364 Standard Specification for Architectural Cast Stone.

All concrete products and many natural stones, under varying conditions of moisture and temperature, are frequently subject to crazing. A manufacturer careful in proportioning of designs and watchful of compaction techniques and curing methods will minimize the likelihood of crazing as a result of manufacturing causes.

Crazing has been a subject of concern for producers of concrete products for as many years as concrete has been in existence. The appearance of small cracks on the surface, especially when filled with dirt, can be alarming since most people will assume that the product has failed, thinking that the fissures are running through the entire cross section.

Crazing can be caused by any factor, which causes surface tension in excess of interior tension. Manufacturing causes include inadequate or improper curing, a surface film richer in cement and fines than the body of the concrete and plastic shrinkage cracking. Crazing can also be caused by design and installation factors which cause unusually high amounts of vapor transmission, excessive wetting and drying or inadequate ventilation behind the Cast Stone. There is some evidence that atmospheric carbonization can cause crazing.

Common installation problems which can cause or enhance crazing include the use of through-wall flashing without adequate drainage or masonry bond, lack of sufficient weep holes, use of Cast Stone without ventilated wythe, use of Cast Stone below grade or at planter type areas without proper moisture barrier, failure of joint materials which allow water entry, the use of hard mortar joints where sealant joints should be used and lack of sufficient allowance for movement via control joints.

Since crazing is only on the surface, the visual attributes can usually be removed by washing the affected areas with a mild acid solution. Severe cases of crazing may require application of a siloxane sealer, following etching, to penetrate the cracks and to keep dirt from settling into the surface.

Manufacturers of Cast Stone who experience crazing should review their mix designs, as well as compaction and curing techniques with the Institute and pay particular attention to the design and installation details, which can cause crazing, during the shop drawing submission process.

Design professionals should ensure that the wall section details provide adequate ventilation and drainage behind Cast Stone and above flashing. Sealant joints should be used in accordance with CSI specifications and wherever thermal movement is likely.
DESIGN TIPS – TECHNICAL BULLETIN #45
DEGREES OF CUSTOMIZATION [1 of 2]

Improvements in the availability and economy of Cast Stone can often be achieved when the specifier balances the needs of a project with the degree of custom shapes needed for the cast stone installation. The indirect labor costs of design, layout, supervision, coordination and mold making needed for a “full custom” project can greatly exceed the actual direct cost of just casting and delivering a basic or standard product to the jobsite. This causes wide variances in the price of Cast Stone and places a premium on the product, which is not always necessary. With the foregoing in mind, Cast Stone projects will generally fit into one of the following categories: Standard, Semi-Custom or Custom.

Standard Cast Stone items are purchased according to a manufacturers catalog, shop drawing or inventory of molds. They may be ready made items or made to order. The units are usually priced individually. The architect or contractor determines the quantities and location of each unit on the structure as well as the method of anchoring to the structure, if required. The Cast Stone manufacturer provides no layout drawings. Cutting of units in the field is usually required.

Semi-Custom Cast Stone items are purchased according to unit shapes shown on contract documents or according to shop tickets specially prepared to define the scope of the work. They are usually made to order either from custom or inventoried molds. The units may be priced either individually or as a lump sum contract for the project. The Cast Stone manufacturer prepares shop tickets for approval, which show the quantities, cross section, reinforcement, finished faces, anchoring provisions and a schedule of lengths to be provided. The architect or contractor confirms the quantities, sizes and location of each unit on the structure as well as the method of anchoring to the structure, if required. The Cast Stone manufacturer provides no layout drawings. Some cutting of units in the field may be required.

Custom Cast Stone items are purchased strictly according to contract documents and according to shop drawings specially prepared to confirm the scope of the work. They are usually made to order from custom molds. The units are usually priced as a lump sum contract for the project, according to plans and specifications. The Cast Stone manufacturer prepares shop drawings for approval, which show the details of stones, arrangement of joints, quantities, cross section, reinforcement, finished faces, anchoring methods, anchors and the location of the units on the structure. The architect and contractor approve the shop drawings to confirm the Cast Stone manufacturers interpretation of the contract documents, quantities, sizes, location of each unit on the structure, method of anchoring to the structure and coordinate the interface of the Cast Stone with other trades. The Cast Stone manufacturer normally provides layout drawings. Cutting of units in the field is usually not required.

In many specifications today, architects are requiring layout drawings that call for the location of every joint on the building facade to be precisely located, while others desire standard products and consider custom products to be cost prohibitive. Methods are available for controlling joint locations when using semi-custom typical lengths and standard products as described herein and they should be used whenever possible.

Where jointing layouts are not clearly shown on contract documents or where shop drawing requirements are not clearly spelled out in the project specifications, misunderstandings and disappointment can develop between the architect and Cast Stone manufacturer, unless the parties first agree that the job will be fully custom in nature.

When the architect implements a standard or semi-custom design, which commits to a certain number of shapes and sizes, the approval process is significantly streamlined and delivery times are shortened. The masonry contractor may choose to receive a neat pallet of modular units, which can easily be cut to fit the exact as-built dimensions at the jobsite.
DESIGN TIPS – TECHNICAL BULLETIN #45
DEGREES OF CUSTOMIZATION [2 of 2]

For most installations, typical lengths will be the common unit, with 4’-0” modules (3’-11 5/8”) as the most popular size. Longer lengths are available but should generally not exceed 15 times the minimum cross section thickness. Control joint spacing should divide evenly by the size of the typical unit. Special corner and end units should be cast to suit the end-of-wall condition and intermediate units may be cut with a standard abrasive blade masonry saw. Stones with any exposed reinforcement, including stone that has been cut to expose rebar, should not be set without following the procedure set out below.

A typical fitting specification should include the following:
1. Follow architect’s jointing pattern as shown on contract drawings.
2. If necessary, cut units to suit in-place wall dimensions.
3. All window and door surrounds shall consist of evenly sized units.
4. All exposed reinforcement is to be cut back to a minimum depth of 1 1/2”.
5. Apply zinc primer or Sika Armatec 110 EpoCem reinforcement protection or equivalent to all exposed reinforcement before setting stone.
6. Fill recessed pocket containing coated reinforcement with repair material.

Window sills should be sized to fit the masonry opening or mullion spacing, with allowance for 3/8” joints. The height of all Cast Stone, which is built into masonry walls, should match the brick coursing. Profiles should be designed with the Cast Stone Institute® Value Engineering suggestions at hand.

Standard Cast Stone jobs are best suited for designs that call for basic and popular items such as band courses and wall cap coping, pier caps, keystones, quoins and window sill units sized to replace brick. Semi-custom projects can include almost any application where the designer is willing to dimension the stone units on the contract documents.

Custom Cast Stone designs represent the majority of buildings under construction today. Layout drawings are needed for projects that have many different profiles running through changing wall sections or one-of-a-kind installations such as entrances, porticos and signs. Base courses of stone at changing grade elevations, radius walls and applications suspended from structural concrete or steel are other good applications for custom Cast Stone.
CARE & MAINTENANCE – TECHNICAL BULLETIN #33
EFFLORESCENCE

Efflorescence is a crystalline deposit, usually white, on the surface of masonry walls and concrete products. All masonry and concrete materials are susceptible to efflorescence. It is due to moisture entering through the walls or the surface of the Cast Stone, combining with the calcium hydroxide in the cement, and bringing the hydroxide to the surface in a solution which forms a more insoluble compound when it combines with the carbon dioxide in the air. Efflorescence has no structural or durability significance and does not by itself constitute a cause for rejection according to ASTM C 1364, Standard Specification for Architectural Cast Stone.

Efflorescence is unsightly and is usually a source of disagreement between builders and architects as to why it occurs and what should be done about it when it appears. It is not always possible to predict whether masonry will effloresce. Soluble salts and moisture must be present for efflorescence to occur. These salts may be present in the concrete, mortar, brick or Cast Stone. They may be carried into the wall with rainwater or absorbed by groundwater. Planter areas and water table sections must be properly damp proofed (see section on damp proofing) to prevent wicking of groundwater. Improper ground storage is a common cause of salt contamination. There is some evidence, which suggests that salts can be interjected with admixtures, deicers or with masonry cleaners. While acids are frequently used to remove efflorescence, they can contain chlorides, which contribute to efflorescence. This is one reason why many buildings show signs of efflorescence shortly after wash down.

ASTM C 67 - Standard Test Methods of Sampling and Testing Brick and Structural Clay Tile, includes a wick test for ascertaining whether a brick is liable to cause efflorescence. Small specimens or cubes either molded or saw cut from Cast Stone may be evaluated by this test.

Common installation problems which can cause or enhance efflorescence include the improper use of through-wall flashing, lack of sufficient weep holes, use of Cast Stone without ventilated wythe, use of Cast Stone below grade or at planter type areas without proper moisture barrier, failure of joint materials which allow water entry and the use of hard mortar joints where sealant joints should be used. Soffit stones are particularly susceptible to efflorescence from masonry walls above and should be designed to prevent them from becoming the “gutter” of the wall.

Most efflorescence is temporary and, as such, should be left alone. It most commonly occurs shortly after building wash down and in the fall and winter months when vapor transmission slows down and masonry stays damp for extended periods of time. Calcium hydroxide is much more soluble in water at cold temperatures than at warmer temperatures this is another reason why efflorescence is more common in the winter than in the summer. Acid rain is a natural remover of efflorescence since most salts are highly soluble in water. Leaving of joints open during winter construction is a major cause of calcium hydroxide deposits showing up on brickwork in the spring.

If necessary environmental considerations are taken, a dilute solution of muriatic acid (5-10%) will remove common efflorescence as well as any carbonate of lime which may be present. Manual washing can often draw additional salts to the surface and repeat washing may be necessary, but when all of the salts have come to the surface naturally and been washed off there will be no more trouble from this cause.

For more information and a detailed discussion of efflorescence please go to:
DESIGN TIPS – TECHNICAL BULLETIN #47
FLASHING, WEEP HOLES AND RELATED ANCHORAGE [1 of 8]

Proper flashing and weep holes are essential elements in exterior masonry walls. Together, they provide a means to control moisture in a wall. If not addressed, moisture can have damaging effects on exterior walls. Excessive moisture within masonry can lead to crazing, efflorescence and spalling in some cases. Improper flashing can lead to moisture in the interior of a building. An effective system to deal with exterior moisture penetration is necessary for a properly functioning Cast Stone wall.

A drainage wall, also known as a cavity wall, is the most effective solution for a Cast Stone wall exposed to the elements.

THE DRAINAGE WALL
A drainage wall has five essential elements.
- Exterior wythe of masonry
- A clear cavity, or air space, of at least 1 inch
- An interior wythe of masonry or other backing material
- Flashing at all interruptions in the drainage cavity
- Weep holes at all flashing locations. Recommended spacing of 24 in. o.c.

The exterior wythe provides first resistance against moisture penetration. Cast Stone should be laid with full joints in mortar meeting the requirements of ASTM C 270, Type N mortar. (See Bulletin #42.) Care should be taken when laying the stone to ensure the cavity behind this wythe stays clear. A tapered bed joint can help minimize mortar droppings and protrusions into the drainage cavity. A minimum 1 in. cavity or air space is recommended. Cavities of 2 in. or more are easier to keep clear of mortar and debris. Cavities over 4 in. may require special ties and anchors. When insulation is specified, the clear space of the cavity is measured from the outer face of the insulation to the back of the exterior wythe. (See Detail 4.)

Through-wall flashing and weep holes should be used at the base of the drainage wall and at all interruptions in the cavity, such as at window heads and relieving angles. Flashing must be continuous and properly lapped and sealed at the base of the wall and at relieving angles. When flashing is used over openings, such as at windows, end dams are required. (See Detail 1.) Weep holes direct water from the drainage cavity to the outside. Open head joints of at least 1 in. in height are recommended. Open weep hole joints provide the best drainage. They should be spaced no more than 24 in. apart. Rope wicks can also be used, but weep holes should be placed closer together, at 16 in. o.c., since this type does not drain as quickly. Plastic tubes are not recommended because they are easily clogged by mortar or by insects. In stones over 24 in. in length, a 3/8 in. wide by 1 in. high notch through the base of the stone is recommended for drainage. Unnecessarily long lengths of stone are discouraged because adequate drainage between weep holes can be a problem. Moisture retained in the wall can lead to crazing of the Cast Stone.

FLASHING AT BASES
Flashing and weep holes must be used at the base of a cavity (drainage) wall and at all relieving angles. Flashing should extend from the exterior face of the Cast Stone wythe into the cavity. In the case of a masonry backing wythe, the flashing should be turned up a minimum of 8 in. and extend into the masonry backing. In framed backing walls, the flashing should extend up the cavity at least 8 in. and be attached to the exterior sheathing. Building paper or other water resistant membrane on the interior wythe should overlap the top of the flashing.

Flashing is also recommended below all Cast Stone belt courses and watertables that sit on a relieving angle or occur at a change in material, i.e. stone to brick. In most cases, flashing and weep holes should be placed directly below the Cast Stone course for proper drainage of the cavity. In cases where stone and clay brick are used together in the same wythe, the flashing also serves as a bond break between the Cast Stone and the brick.
DESIGN TIPS – TECHNICAL BULLETIN #47
FLASHING, WEEP HOLES AND RELATED ANCHORAGE [2 of 8]

Because clay brick undergoes irreversible moisture expansion and Cast Stone, like other cementitious products, tends to shrink, flashing between the different courses allows horizontal movement to occur without cracking the mortar joints or units. The Brick Industry Association’s Technical Notes 18 Series provides further information on this topic. Stones must be anchored, top and bottom, to the backing material when this detail is used.

FLASHING OVER OPENINGS
Cast Stone window heads and arched openings also require flashing. If the Cast Stone is supported by a relieving angle, flashing and weep holes are located below the stone course, on the relieving angle. When no relieving angle is used, as in the case of structural stone lintels, flashing should be placed directly above the stone course. In either case, proper anchorage of the stone to the backing is imperative.

FLASHING AT COPING AND CAPS
Experience has shown that Cast Stone coping perform best when the mortar bond with the masonry wall is maintained. For this reason, flashing should not extend over the full width below the Cast Stone coping. Instead, the flashing should be turned down into the drainage cavity and then out through the exterior supporting wythe below. (See Detail Plates 5, 6 & 7) This prevents the potential for water to pond underneath, which can deteriorate the mortar through the freeze-thaw process. In extreme cases, even the cast stone may be damaged due to repeated cycles of freezing and thawing while critically saturated for extended periods of time. This differs from recommendations found in the Brick Industry Associations Technical Notes.

At chimney caps, step flashing from below the Cast Stone coping down through the first course of supporting masonry below the weep holes should be located in the head joints of the first course of supporting masonry. (See Detail 3.)

ANCHOR PENETRATIONS THROUGH FLASHING
The anchors for attaching Cast Stone may be required to penetrate flashing and building paper to allow a secure connection to the structure. Where this occurs, proper steps must be taken to ensure a watertight connection at the interface so that the anchor does not compromise the integrity of the flashing. Grommets, thimbles, sleeves, couplings and sealants are available for this purpose, but it is beyond the scope of this Technical Bulletin to provide specific guidance.

FLASHING MATERIALS
Flashing is a key element in a drainage wall. Poor flashing materials can become brittle over time and may allow water to penetrate the building interior. As a result, longevity and life cycle cost should be considered, in addition to first costs, when choosing a flashing material.

Flashing materials used successfully with Cast Stone include stainless steel, copper, copper laminates, EPDM, and rubberized asphalt. Polyvinyl chloride (PVC) and galvanized steel flashing should be avoided because of their questionable long-term performance. (See the Brick Industry Associations Engineering & Research Digest, “Through-Wall Flashing”, for a detailed discussion.) Table 1 lists some advantages and disadvantages of each of the recommended flashing materials that must be considered in making a final selection.
### DESIGN TIPS – TECHNICAL BULLETIN #47
### FLASHING, WEEP HOLES AND RELATED ANCHORAGE [3 of 8]

#### Table 1: RECOMMENDED FLASHING MATERIALS

<table>
<thead>
<tr>
<th>Material</th>
<th>Minimum Thickness</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>0.01 in. (0.25 mm)</td>
<td>Extremely durable, non-staining</td>
<td>Difficult to solder and form</td>
</tr>
<tr>
<td>Cold Rolled Copper</td>
<td>10 ounces/ft² (3100 g/m²)</td>
<td>Durable, easily formed, easily joined</td>
<td>Stains adjacent masonry</td>
</tr>
<tr>
<td>EPDM</td>
<td>30 mils (0.8 mm)</td>
<td>Flexible, easy to form, easy to join, non-staining</td>
<td>Metal drip edge required more easily torn</td>
</tr>
<tr>
<td>Rubberized Asphalt</td>
<td>30 mils (0.8 mm)</td>
<td>Self-healing, flexible, easy to form, easy to join</td>
<td>Dimensional instability, incompatibility with joint sealant, metal drip edge required</td>
</tr>
<tr>
<td>Copper Laminates</td>
<td>5 ounces/ft² (1500 g/m²)</td>
<td>Easy to form, easy to join, non-staining</td>
<td>Metal drip edge required, more easily torn</td>
</tr>
</tbody>
</table>

Table printed with permission from the Brick Industry Association Engineering & Research Digest, “Through-Wall Flashing.”
ANCHORING AND FLASHING DETAILS

These are typical connections recommended by the Cast Stone Institute for similar applications. Consult your engineer for size and connection requirement before ordering anchors.

DETAIL 1 - "Z" STRAP ANCHOR @ HEADER

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 3/4"-1".
Typical thru hole diameter is 1/2" larger than the fastener.
For example, using a 3/4" self tapping metal screw the diameter would be 1/2".

DETAIL 2 - "L" STRAP W/ WELDED DOWEL PINS @ JAMB

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 3/4"-1".
Typical thru hole diameter is 1/2" larger than the fastener.
For example, using a 3/4" self tapping metal screw the diameter would be 1/2". Typical hole size is 3/4" larger than all thread.
DESIGN TIPS – TECHNICAL BULLETIN #47
FLASHING, WEEP HOLES AND RELATED ANCHORAGE [5 of 8]

Anchoring and Flashing Details
These are typical connections recommended by the Cast Stone Institute for similar applications. Consult your engineer for size and connection requirement before ordering anchors.

DETAIL 3-"L" STRAP W/ WELDED DOWEL PIN @ SILL

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 3/4"-1".
Typical thru hole diameter is 3/8" larger than the fastener.
For example, using a 3/8" self tapping metal screw the diameter would be 5/32". Typical hole size is 5/32" larger than all thread.

DETAIL 4-"SPLIT TAIL" STRAP @ VENEER

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 3/4"-1".
Typical thru hole diameter is 3/8" larger than the fastener.
For example, using a 3/8" self tapping metal screw the diameter would be 5/32". Typical hole size is 5/32" larger than all thread.
DESIGN TIPS – TECHNICAL BULLETIN #47
FLASHING, WEEP HOLES AND RELATED ANCHORAGE [6 of 8]

Anchoring and Flashing Details
These are typical connections recommended by the Cast Stone Institute for similar applications. Consult your engineer for size and connection requirement before ordering anchors.

DETAIL 5-“L” STRAP W/ WELDED DOWEL PINS @ COPING

DETAIL 6-WELDED DOWEL PIN AND PLATE @ COPING

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 2"-1".
Typical thru hole diameter is \( \frac{D}{2} \) larger than the fastener.
For example, using a \( \frac{3}{8} \) self tapping metal screw the diameter would be \( \frac{\frac{3}{8}}{2} \). Typical hole size is \( \frac{3}{8} \) larger than all thread.

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
ANCHORING AND FLASHING DETAILS

These are typical connections recommended by the Cast Stone Institute for similar applications. Consult your engineer for size and connection requirement before ordering anchors.

DETAIL 7-DOWEL PIN @ COPING

Typical "A" dimensions are 2"-6", with the most common being 4". Typical diameter varies from 3/4"-1" depending on the size of the stone. Most commonly used are 1 1/8" diameter x 4" LG. Field drill 1" diameter x 2" deep hole in to filled CMU and fill with non-shrink grout. Typical hole size is 1/2" larger than all thread.

DETAIL 8-FERRULE LOOP INSERT @ HEADER AND SOFFIT

Typical "A" dimensions are 3/8"-1", with the most common being 3/4".
Anchoring and Flashing Details

These are typical connections recommended by the Cast Stone Institute for similar applications. Consult your engineer for size and connection requirement before ordering anchors.

**DETAIL 9-TYPICAL ANCHORAGE @ CORNICE**

Typical "A" dimensions are 1"-2".
Typical "B" dimensions are 1"-2".
Typical "C" dimensions are from center of stone to the face of sheathing/outside face of wall structure.
Typical "D" dimensions are 3/4"-1".
Typical thru hole diameter is 3/8" larger than the fastener.
For example, using a 1/4" self tapping metal screw the diameter would be 5/32".

**DETAIL 10-FIELD CUT REGLET**

Typical installer field cut reglet.
This should be cut at a 45° angle, 1"-2" deep and 3/4"-3/8" wide. Fill with construction adhesive and add flashing by installer.
Design Tips – Technical Bulletin #40
Freeze/Thaw Durability

Architectural Cast Stone is a product, which has been used for many decades in all types of climatic conditions. In order to reasonably assure the user that the Cast Stone being supplied by a particular producer is durable in freeze/thaw conditions, the Cast Stone manufacturer has two options. The first, and most common method is to show the purchaser similar architectural Cast Stone products made from the same materials by the manufacturer, which have been in service for many years. The second option is to subject samples of architectural Cast Stone to laboratory testing.

Recent research has shown that architectural Cast Stone, as well as other dry cast concrete products, can be evaluated for durability when subjected to a modified version of ASTM C 666, Procedure A - Test Method for Resistance of Concrete to Rapid Freezing and Thawing. This technical bulletin outlines the modifications to ASTM C 666, Procedure A that is necessary to properly judge Cast Stone durability performance.

Test Cast Stone using ASTM C 666, Procedure A, but evaluate the product based on cumulative percent weight loss and not its relative dynamic modulus of elasticity or durability factor as is described in ASTM 666. Research has shown that certain cast stone may have a high durability factor, but its outer surface may deteriorate badly. Therefore, cumulative percent weight loss is more representative of the aesthetic performance of Cast Stone.

After the Cast Stone is 14 days of age or older, wet saw three 3” x 4” x 16” (76 mm x 102 mm x 406 mm) beams from a single sample of cast stone to represent three specimens for a single test. One surface of each beam is to be from the exposed formed face of the sample, and the remaining sides shall be cut from the sample with saws. The allowable size tolerance of the specimens shall be ± 1/8 inch (3.2 mm). Do not oven dry the beam specimens until all freeze / thaw cycles are completed. Submerge each beam specimen in lime-saturated water at 73.4 ± 3° F (23 ± 1.6°C) at least 48 hours prior to beginning freeze / thaw cycling. Subject each beam to freezing and thawing as described in Method C 666, Procedure A. Inspect each specimen every 30 to 36 cycles and collect all spalled material caused by freeze / thaw cycling from each specimen individually to monitor weight loss during testing. For each specimen, oven dry and weigh the spalled material until loss in mass is not more than 0.2% in two hours of drying. Record the data individually and cumulatively for each specimen throughout the test until 300 cycles are completed, or 10% of the specimen’s estimated mass has been lost due to spalling, whichever occurs first. Specimens for this test shall then be oven dried at a temperature of 212 to 230° F (100 to 110° C) until the loss in mass is not more than 0.1% in 24 hours of drying. They shall be removed from the oven and allowed to cool at room temperature for approximately 30 minutes before measuring final dry weight. The initial dry weight of each specimen is considered to be the final dry weight of the specimen plus the total dry weight of spalled material collected from the beam throughout the test.

Calculate the cumulative percent weight loss for each beam specimen as follows:

\[
CPWL (Beam) \% - \frac{S}{(S+B)} \times 100
\]

where:

- \( CPWL (Beam) \) = Cumulative Percent Weight Loss,
- \( S \) = Total Dry Weight of Spalled Material, and
- \( B \) = Oven Dried Beam Weight at the end of the test.

Calculate the Cumulative Percent Weight Loss, CPWL, for the sample. The CPWL of the sample is the average CPWL (Beam) of the three specimens.

The CPWL shall be less than 5% after 300 freeze / thaw cycles.

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
DESIGN TIPS – TECHNICAL BULLETIN #48
HOT WEATHER SETTING PRACTICES [1 of 2]

Special precautions must be taken when setting Cast Stone in hot weather. The installer must take measures to ensure that the quality of the Installation does not suffer from high temperatures. Hot weather is defined to be temperatures above 90°F (32°C).

The primary concern, to the masonry contractor during hot weather, is evaporation of water from the mortar. If sufficient water is not present, bond between the Cast Stone unit and mortar will be compromised. The increased rate of hydration of the cement and favorable curing conditions in hot, humid weather will help develop masonry strength provided sufficient water is present at the time of construction and for a curing period of three days.

Temperature of the materials can be adjusted to aid the construction of quality masonry in hot weather conditions. ACI 530.1 specifies construction methods to produce quality masonry in hot weather conditions.

Cast Stone units are one of the materials in masonry construction least effected by hot weather. However, the interaction between the Cast Stone and the mortar or grout is critical. As the temperature of the Cast Stone units increase, they will absorb more water from the mortar. Lower bond strength between the mortar and the units may result if enough water is not present in the mortar when the units are laid. Thus, lower absorption units may be desirable since they allow more complete hydration of the mortar.

MORTAR:
According to the Industry Associations e.g. Brick Industry Association (BIA), Mason Contractors Association of America (MCAA), National Concrete Masonry Association (NCMA) and the Portland Cement Association (PCA) mortar in hot weather will tend to lose its workability rapidly due to evaporation of the water from the mix and the increased rate of hydration of the cement. The use of admixtures (sometimes called modifiers) to increase workability is not recommended unless their full effect on the mortar is known and that they comply with ASTM C 1384 – Standard Specification for Admixtures for Masonry Mortars. Retempering of the mortar should be permitted except for pigmented mortars. Mortar mixed at high temperatures often has higher water content, lower air content, and a shorter board life than those mixed at normal temperatures.

Mortar temperatures need to be controlled per the ambient air temperatures as specified in ACI 530.1. The installer should follow the requirements in The Masonry Industry Council’s (BIA, MCAA, NCMA & PCA) Tables 1 & 2 for temperature control. High mortar temperatures will affect the mortars set times. Mortar temperatures above 120°F (49°C) may cause flash set of the cement. Cold water may be used to help control the temperature of the mortar. Ice is highly effective in reducing the temperature of the mix water. When used, ice should be completely melted before combining the water with any other ingredients. In any case, mortar should be used within two hours of initial mixing.

During periods of hot weather the temperature of the materials should be controlled for best results. Storing Cast Stone units and sand under cover of shade will help control heat gain of the materials. Sand should be stored on a raised platform and not in contact with a cover during the hot part of the day. Sand piles should be kept in a damp condition by sprinkling with water during times of high evaporation. This can help lower the temperature of the sand through evaporative cooling.

When possible, shade should also be provided for laborers, whose productivity decreases with increasing temperature and humidity. Starting work earlier in the day and scheduling masonry construction, avoiding the hot mid-day periods, can reduce the effect of high temperatures on laborers and materials.
DESIGN TIPS – TECHNICAL BULLETIN #48
HOT WEATHER SETTING PRACTICES [2 of 2]

The following items are suggested for hot weather masonry construction. These items can be incorporated in the specifications of the project where applicable:

1. Mixers, mortar pans, wheelbarrows, mortar boards and other tools should be moistened with water prior to use to reduce their temperature.
2. Mix small batches and avoid prolonged mixing of mortar. Ice may be used to lower the mix water temperature and must be completely melted before adding the water to the other ingredients. Cold water should always be used when mixing mortar and grout. Use the mortar within 2 hours of the initial mixing.
3. The surfaces of the Cast Stone should always be thoroughly moistened with potable water prior to setting. This procedure is even more critical during hot weather.
4. Limit the spread of mortar beds to 4 ft (1.2m) ahead of the Cast Stone units when temperatures are 100° F (38° C) or above, or 90° F (32° C) with an 8 mph (3.6 m/s) or greater wind.
5. Place Cast Stone within one minute of laying mortar. Fog spray all newly constructed masonry units, until moist, at least three times a day.
6. Cover the units at the end of the day with plastic sheets to control moisture evaporation.

Note: Construction requirements, while work is in progress, are based on ambient temperatures. Protection requirements, after masonry is placed, are based on mean daily* temperatures.*The temperature calculated to be the average of the extremes forecast by the local weather bureau over the next 24 hours.
DESIGN TIPS – TECHNICAL BULLETIN #36
INSPECTION AND ACCEPTANCE [1 of 2]

On site inspection and acceptance of Cast Stone should be performed at time of delivery and again after all material has been installed, pointed and cleaned. Final Inspection should be done prior to application of water repellents. The on site inspector should be familiar with the project specification as well as the applicable referenced standards. Test reports of compressive strength, absorption and other physical properties should be on file as well as the approved sample.

Before installation, check the color and texture of the approved sample against the delivered product. Cast Stone should approximate the color and texture of the approved sample when viewed under good typical lighting conditions at a 10-foot distance and should show no obvious imperfections other than minimal color and texture variations from a 20-foot distance. In addition to issues concerning color and texture, the inspector (and stone setter) must be familiar with the dimensional requirements of the installation as they pertain to joint sizes and interfaces with other materials.

Stones should always be appraised for color when dry as dampness will darken the surface color and make it appear blotchy. Curing time differential may affect color since moisture will be retained within units for 6 months even in dry weather. Samples, which have been stored indoors for long periods of time, may look considerably different than product, which was, manufactured only a short time before delivery. Texture of Cast Stone should be approximately equal to the approved sample when viewed from a 10’ distance in good typical lighting. Do not appraise texture under a sun wash when sunlight is skimming across the surface parallel to the plane of the stone face, as this will unfairly accentuate minor irregularities.

Minor variations in color and texture from stone to stone should be accepted within the limits of the accepted range, either established by several samples or mockups or by deviations from instrumentally measured color coordinates. In general, expect color variation to be approximately equal to a good natural cut limestone project. More color variation should be expected than from building materials with painted or applied finishes.

Some projects will show more color variation than others. Units containing gray cement will show more light-dark variations than those containing white cement. Colors, which require high amounts of integral pigments such as reds and browns, will vary more than moderately neutral shades such as buff. Special mixes containing contrasting and multi-colored aggregates may be subject to extreme color deviations when compared to homogeneous facing mixes.

Variations in color within the same stone may be caused by efflorescence or free lime migrating to the outer surface. This can usually be remedied by proper wash down. Staining, mortar smears or uneven washing can also cause color variations within stones and the manufacturer should be consulted for recommended treatment of these problems.

Touch and repair is perhaps the greatest source of dissatisfaction with finished installations. When months have elapsed between the date of manufacture and the date of repairs, significant differences in color may exist between properly repaired areas and the remainder of the stone. These areas should be left alone and will blend in over time through curing, natural weathering and ultraviolet light. It is a mistake to require an instant color match at time of repair since this will usually cause dark patches later on.

Common deficiencies, which are not normally acceptable in high quality Cast Stone installations include:
1. Bug holes or air voids on the finished surfaces.
2. Ragged or chipped edges on formed edges.
3. Stains on exposed faces from foreign substances.
4. Twist, warp, out of square or bow exceeding tolerances.
5. Out of plane or pie shaped joints, or large or small joints out of tolerance.
6. Areas of rough texture or smoothness not matching sample from 10’.
7. Backup concrete bleeding through exposed faces.
8. Visible cracks exceeding 0.005”.
9. Reinforcing shadows or exposure on face.
10. Rust on surface caused by staining, reinforcement or iron pyrites.
11. Installation not matching joint layout on approved shop drawings.
12. Form marks or local depressions in excess of 0.030”.

Building owners and their representatives will often apply some wishful thinking when viewing and touching a small 12” sample and then trying to imagine the way an entire facade will look. Wherever possible, an investment should be made in mockup panes and/or sample units. The sample units should demonstrate a variety of shapes and casting configurations, including vertically cast surfaces if they are to be encountered.

Careful quality control of Cast Stone units by competent personnel at the plant combined with qualified ongoing inspection and acceptance at the job site ensures that all parties are aware of each others expectations. This eliminates disappointing results at the end of the job since very little can be done to change the appearance of Cast Stone after it has been set into the structure.
DESIGN TIPS – TECHNICAL BULLETIN #37
JOB SITE HANDLING AND INSTALLATION [1 of 2]

The on-site personnel should be familiar with the applicable sections of the Cast Stone Institute® Specifications and the Project Specification pertaining to delivery, storage, setting, touch and repair, cleaning, pointing, caulking and sealing. In case of a conflict between the two specifications, the Project Specification should prevail. Where the Project Specification may not include a particular issue, the Industry Standards should be followed.

The following checklist has been developed for Cast Stone installations.

1. Prior to delivery there should be a set of the approved shop drawings and the approved color and texture sample on file. All test reports specified should be submitted as required.
2. Upon delivery, all Cast Stone should be checked for chips, cracks, stains, or broken pieces. Any damage should be noted on the delivery slips and communicated to the manufacturer or the sales representative.
3. Color and texture should be inspected in accordance to approved color sample or mock-up panel set up at the job site. In general, the color and texture of the Cast Stone delivered to the job site should be approximately equal to the approved sample when viewed in good typical daylight conditions at a ten foot distance. (See technical literature on Inspection and Acceptance.)
4. Storage of Cast Stone should be above the ground on non-staining planks or pallets. The storage site should be away from heavy construction traffic. Cast Stone stored for an extended period of time should be kept on pallets or non-staining planking and covered with non-staining tarpaulins. Allow for air circulation.
5. Prior to setting, insure climatic conditions are within thermal limitations of mortar. Mortar retarders and accelerators should be used according to manufacturer’s directions but not with touch and repair material. Set stone in full mortar joints and fill all dowel holes and anchor slots completely with mortar. Insure uniform joint widths within specifications tolerances.
6. Ensure that all specified flashing and damp proofing is installed. Flashing pierced by stone anchors must be sealed either by metal thimble, grommet or approved sealant.
7. Concrete should never be poured against unprotected Cast Stone. Where poured in place, concrete is placed against Cast Stone sills, separate with appropriate material prior to pouring concrete.
8. Stone anchors must meet specified standards and be non-corrosive. Stone slots to receive anchors should be completely filled with mortar.
9. Prior to setting insure that the surfaces set in mortar are drenched with water. This will secure a good bond and help to prevent mortar shrinkage.
10. Weep holes must be installed over windows, at relieving angles and at the V bottom of walls. No mortar drippings shall be allowed in the wythe between back of stone and face of back-up structure.
11. All head joints at coping and sills, and joints at column covers, soffits, and, in general, all stone sections with projecting profiles, exposed top joints or rigid suspension connections to the supporting structure should be sealant joints. Only the ends of load bearing lug sills shall be set in a full bed of mortar to prevent cracking from future wall settlement. After setting, prime the joints, insert properly sized backup rod and gun in sealant.
12. All trim items except parapet coping must align with control joints. Do not bridge coping over expansion joints.
13. Cast Stone should be handled to minimize chipping. Care must be taken not to bump the stone into anything. Handle stones with the wide portion of the cross section in the vertical position to minimize breakage.
14. After setting, columns, pilasters, entry jambs, window sills and all stone with projecting profiles should be protected during the remaining construction.
15. During construction, cover open walls when rain is anticipated.
16. Chipped Cast Stone must be patched by skilled mechanics. A trial patch must be approved before general touch and repair is to commence.
17. Planter coping, fountain coping, swimming pool coping, treads, risers, stone pieces at grade, and pavers should be treated with a silane or siloxane water repellent after setting. This will minimize the likelihood of dirt and groundwater entering the surface of the stone; a frequent cause of staining, efflorescence and enhancement of crazing. Check that water repellent does not affect color or texture when dry.

18. Load bearing units should be reinforced as necessary. They may not be designed to be handled in a different orientation than they will be installed in the structure. Lintels and large panels must be kept vertical.
Selection of the correct grade of mortar is perhaps the most important factor in the performance of a masonry wall. The mortar must have sufficient strength, be durable, resist rain penetration as much as possible and yet be flexible enough to accommodate slight movement within the wall.

Mortars used in the setting of Cast Stone should meet the requirements of ASTM C270, Type N mortars. These Portland cement/lime mortars generally consist of one part cement (ASTM C150), one part lime (ASTM C207) and six parts of clean, washed masonry sand (ASTM C144). They may also contain iron oxide coloring pigments (ASTM C979).

The 1/1/6 mixture provides good bond strength with desired weather resistance and moderate compressive strength relative to the stone when cured. The lime enhances the workability of the mortar while reducing shrinkage. The practice of wetting the head and bed joints of the stone will further protect against joint shrinkage.

Although Type N mortar is the standard used in Cast Stone (as well as many natural cut stone) applications, the proportions may be varied to suit specific applications.

Proper mixing is essential to good consistency. All materials except pigments are measured by volume. Sands should be placed in the spiral-blade or paddle type mixer first, followed by pigments (if required), pre-water, lime and cement, final water and 5-7 minutes of mixing time. Mortars unused after 2 ½ hours should be discarded. (This time may be affected by temperature.)

Head joints in most hand set stones may be set with the usual wet consistency mortar used in setting brick and block. Stiffer mortar must be used when setting larger stones and shims are recommended for all pieces over 300 lbs. When setting, fill all dowel holes, anchor slots and similar building stone anchor pockets completely with mortar. Non-shrink grout or anchoring cement may be specified for dowel connections. Caution should be used when the bed joint is on horizontal flashing as it will act as a bond breaker. Special anchorage may be necessary to accommodate this condition.

Mortar systems have the ability to carry loads but cannot absorb much joint movement. For this reason, thoughtful designers often require that joints at parapets, copings and other particularly sensitive areas be left open (unmortared) for later closing with sealants.

When using a post setting pointing system, rake all stone-to-stone joints to a depth of ¾" for pointing later. It should be noted that in many cases (and specifically when setting small veneer pieces) it is not practical to rake out and point all joints. In these instances, full bed setting and finishing in one operation can be used. Particular attention must be paid to the waterproofing systems behind and incorporated into the veneer. Stone-to-brick joints are usually struck and tooled to a slight concave. See Technical Bulletin #44 on Pointing. Sponge all mortar smears from face of stone with water. Hardened, smeared mortar is difficult to remove from the surface of cast stone. Clean with a commercial masonry cleaner approved for use with cast stone or with water and a stiff fiber brush. Consult Cast Stone manufacturer first. Power washers should never be used to clean Cast Stone. See Technical Bulletin #39 on Cleaning.

If lug sills, which extend beyond the masonry opening, are fully set in mortar, the mortar at the ends under the lugs (where the load is) may, in certain situations, compress or shrink more than the rest of the mortar (due to overburden forces), causing shear or bending stress in the sill and possibly leading to failure. One of two additional precautions may be taken when setting lug sills. The first is to set only the ends of lug sills in a full bed of mortar; and point the portion of the sill inside the masonry opening after the initial mortar bed has cured. The other approach is to shim under the lugs to bear any compressive loads. The system designer should examine the lug sill configuration and how it interfaces with the adjacent and under-supporting masonry units to insure that...
point bearing will not occur at the mid-span of the sill. Slip sills, which do not extend past the masonry opening, do not carry any load other than themselves and are set in a full bed of mortar.

The decision on whether to use mortar/pointed joints or sealant joints is a common one. All head joints at coping and joints at column covers, cornices, platforms, soffits, and in general, all stone sections with projecting profiles, exposed top joints or rigid suspension connections to the supporting structure should be "soft" sealant joints. Additionally, when piece sizes are larger than conventional masonry units (1'6" tall by 2'6" in length for vertical applications) “soft” sealant joints are generally recommended, and a professional designer or engineer should be consulted for proper joint design and function. After setting, prime the ends of the stones (if necessary), insert properly sized backup rod and gun in sealant. See Technical Bulletin #43 on Sealants.
CARE & MAINTENANCE - TECHNICAL BULLETIN #38
TOUCHUP AND REPAIR

The best insurance against chipped stone is care in handling and protection of the unit after installation. Even with all of the special care and protection, building stone still becomes chipped from time to time and a certain amount of touch up is to be expected. Damage to stone either while in transit or during installation is usually classified as repair.

Touch up - Any chip obvious from a 20’ distance should be touched up with material provided by the manufacturer. Chips measuring 1/4” and less across the face are usually left alone. The stone mason should include touch up as part of the ordinary pointing and washdown operations prior to final inspection.

Repair – Chips measuring larger than ¼” across the face are usually addressed in a separate operation as soon as possible following occurrence of damage. The procedure for repair will include dressing the damage and applying fresh material to achieve the desired finish and shape, covering the repair with a wet rag and/or plastic cover, then taking steps to blend the repair into the adjacent areas. Stone units with chips larger than 8” square should be replaced, unless the damaged portion can be salvaged and expoxied back to the unit.

Most cracks can be repaired if the units are reinforced. Units which are load bearing should be epoxy injected after the cause of the restrained movement has been identified. Cracks which are observed in installed units can be grouted with native material if the crack is less than .007 in. and the forces which caused the crack have been eliminated.

Climatic conditions must be taken into consideration before repair is to commence. Do not repair stone in freezing weather or if a freeze is anticipated within 24 hours. On hot sunny days repair should be done during the morning hours where the Cast Stone is shaded or at temperatures less than 90 degrees Fahrenheit. Repairs should be covered with a damp cloth and plastic sheet to prevent the cement from hydrating too quickly.

The same material that was used to manufacture the Cast Stone should be used for touch up and repair. Experimental batches should not be used in an effort to obtain an instant color match. The water/cement ratio used should be as close as possible to the mix at the time of manufacture. Acrylic bonding agents may be used, but not in place of water. Use as a wetting agent; less than a tablespoon per handful of the concrete material. Never use metal tools for applying a repair. Stones which were acid etched at the factory will require the same treatment applied to the touch up or repair.

A properly executed repair will not match in color immediately. Dry cast products will appear lighter where repaired; wet cast products may appear darker. Repairs that match, immediately or in two or three days, have a tendency to change color later on after weathering. Through curing, weathering and ultraviolet light, the patch will eventually return to the original stone color. This process could take 3 months to a year or longer depending on the climatic conditions and exposure to the weather.

Repairs which cannot be seen from a 20’ distance when viewed in good typical lighting should be accepted. Request Bulletin #36 on Inspection and Acceptance.
Design Tips – Technical Bulletin #44
Pointing of Joints

Not all joints between stones or between stone and other material should be filled with mortar. For conventional masonry units, all head joints at coping stones and joints at column covers, cornices, platforms, soffits, window sills and in general, all stone sections with projecting profiles, exposed top joints or rigid suspension connections to the supporting structure should be "soft" sealant joints. When piece sizes are larger than conventional masonry units (1'6" tall by 2'6" in length for vertical applications) "soft" sealant joints are generally recommended, and a professional designer or engineer should be consulted for proper joint design and function. See Technical Bulletin #43 on Sealants.

Pointing is required for piece sizes larger than conventional masonry units because mortar shrinks and settles as it cures. Since mortar beds harden from the face in, stresses can be applied to the edge of the stone which can cause spalling later. Shrinkage also can create cracks at the joints; a condition which causes leaking. Mortar joints are best suited for masonry-bound trim items such as belt courses, lintels, window surrounds, date stones, inscription blocks, quoins, keystones and similar applications.

It should be noted that in many cases (and specifically when setting small veneer pieces) it is not practical to rake out and point all joints. In these instances, full bed setting and finishing in one operation can be used. Particular attention must be paid to the waterproofing systems behind and incorporated into the veneer.

Regardless of whether the mortar or sealant is selected as the face joint material, the mortar must be raked out of the joint to a minimum depth of 3/4". If sealant is to be used at the head joints, then mortar is normally not used there at all.

Pointing is usually done in 1 or 2 stages to allow maximum sealing of shrinkage cracking in the mortar. It should not be done in areas exposed to hot sunshine and it is suggested that pointing be accomplished after touch and repair of Cast Stone and before final wash-down.

Apply pointing mortar using proper tools to compress the material against the edges of the stone. A concave joint is recommended for the best protection against leakage although other joint types are often available in the stone setting trade.

Pointing mortar should be softer than the stone so that thermal stress will not cause spalling at the edges of the joints. It is usually slightly drier than normal setting mortar consistency to prevent shrinkage and is usually composed of the following:

- 1 part Portland cement, ASTM C150
- 1 part hydrated lime, ASTM C207
- 6 parts masonry sand, ASTM C144

Coloring may be added to achieve almost any hue, however pointing mortar which sharply contrast the color of the stone may cause staining. Excess pointing material must be sponged away from the face of the stone immediately. Colors added must be natural or synthetic mineral oxides which meet the requirements of ASTM C979 (sun-fast, lime-proof, alkali-resistant) and the dosage must not exceed 10% of the weight of the cement used. Carbon black or ultramarine blue pigments should not be used. In general, pigmentation types and amounts used in the manufacture of Cast Stone can also be used as a starting point when custom blending the pointing mortar to match or complement the color of the Cast Stone.

Always specify a mockup wall when approving final colors and be sure that it has been properly cleaned because cleaning will usually affect the color of pigmented masonry materials.
DESIGN TIPS – TECHNICAL BULLETIN #43
SEALANTS

The decision on whether to use mortar with pointed joints or sealant joints between stones is a common one. For conventional masonry units, all head joints at coping stones and joints at column covers, cornices, platforms, soffits, window sills and in general, all stone sections with projecting profiles, exposed top joints or rigid suspension connections to the supporting structure should be "soft" sealant joints. When piece sizes are larger than conventional masonry units (1'6" tall by 2'6" in length for vertical applications) "soft" sealant joints are recommended, and a professional designer or engineer should be consulted for proper joint design and function.

Mortar joints are best suited for masonry-bound trim items such as belt courses, lintels, window surrounds, date stones, inscription blocks, quoins, keystones and similar applications. Rake and point mortar joints rather than full-bed setting and finishing in one operation. See Technical Bulletin #44 on Pointing.

Sealant joints allow for movement at the vertical joints. Leave head joints dry when setting. An allowance for compression and expansion is required for the system to be effective. After setting, prime the ends of the stones (if necessary), insert properly sized foam backup rod and gun in sealant. If a mortared appearance is desired, a sanded sealant may be used.

Since sealant systems are not intended to bear weight, use plastic setting pads or lead shims when setting the stones. The sealant is not intended to adhere to the foam backer rod. The sealant should adhere to the parallel surfaces only. The foam rod should be placed to a depth approximately equal to the width of the joint.

The most common types of sealants are one-part "moisture cure" or "air cure." Two part systems are also available which require the mixing of materials together to allow chemically induced curing.

The inherent properties of silicone products make them excellent sealant materials. Silicones provide superior weathering resistance and perform over a wide range of service temperatures. They are easy to apply, have low shrinkage rates, and can accommodate high movement. While organic materials tend to crack, dry up, and become brittle or even revert with age, silicones remain flexible and durable.

Two component, polyurethane sealants are tough and elastic, allowing for movement of up to 50% of the joint width. They are also durable, flexible and form a watertight bond with most building materials. According to the manufacturers, these formulations offer weather tight seals in caulking joints today for as long as 20 years under normal application conditions and ten years under severe conditions.

Allowance for thermal and other movement should be within 25% of the joint size. For instance, a normal 3/8" joint should be expected to compress to approximately 1/4" and expand to approximately 1/2" during elongation.

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
DESIGN TIPS – TECHNICAL BULLETIN #51
USE OF REINFORCEMENT [1 of 2]

One of the advantages of Cast Stone over natural stone is its ability to contain integral reinforcement for added strength. This gives the material a distinct advantage by combining the high compressive strength of the stone materials with the tensile strength of billet steel reinforcing bars, to provide safety and control of cracking. Cast Stone is an architectural element, and should not be used to support the building structure or load bearing elements (such as hand rails or windows) which require structural support. A structural engineer should design reinforcement for structural or unusual situations.

The preferred type of steel reinforcement is that which meets the requirements of ASTM A 615/A 615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Reinforced Concrete, unless otherwise specified by the purchaser, according to ASTM C 1364 – Standard Specification for Architectural Cast Stone. Other types of reinforcement include wire reinforcement meeting the requirements of ASTM A 82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement, however, welded wire fabric reinforcing shall not be used in Vibrant Dry Tamp (VDT) products. All types of reinforcement should be shown on the shop drawings that are submitted by the manufacturer for approval.

The size of reinforcing bars is classified by a number that corresponds to its diameter in eighths of an inch. The typical sizes used to reinforce Cast Stone are #3 and #4 which are nominally 3/8” or ½” diameter. Deformed bars, with their deformations, are slightly larger than plain bars and do a better job of bonding with the concrete and resisting tension.

Some manufacturers use fiber reinforcement to control plastic shrinkage and thermal cracking. This secondary reinforcement in the form of fibrous nylon meeting the requirements of ASTM C 1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete may be used, but is not a substitute for conventional steel reinforcement.

It is important to understand that Cast Stone units do not always need integral reinforcement included in their design. Many typical applications such as where the material is used as a replacement for natural stone, masonry units or other non-structural applications do not benefit from steel to control cracking. In general, steel should be added to the design only when necessary for safe handling, setting and structural stress.

Typical minimum reinforcement for all other units shall be not less than 0.25% of the cross section area. Units less than 24” in their transverse direction are typically reinforced only in the longitudinal direction. Non-structural units less than 24” in both directions can generally be manufactured as non-reinforced units. Panels, soffits and similar stones measuring greater than 12” high and 24” long, which span openings or carry their own weight should contain reinforcing. Lintels, units supported by suspension connections and other structural applications should have reinforcing requirements reviewed by a professional engineer.

The minimum concrete cover for all reinforced units is twice the diameter of the reinforcing bars and should be non-corrosive when covered with less than 1-1/2” of material. Non-corrosive bars should be touched up with zinc or epoxy paint wherever they have been cut through to plain steel during the reinforcement fabrication process.

The tying together of reinforcing sections prior to unit fabrication is not usually required with the Vibrant Dry Tamp (VDT) units because the reinforcement is embedded into a layer of consolidated fresh concrete material during the manufacturing process. Some structural applications however may require flat bar mats to be used. The use of three-dimensional reinforcing cage assemblies with stirrups is not appropriate for Vibrant Dry Tamp (VDT) units because of the non-fluid nature of this consolidation process.
DESIGN TIPS – TECHNICAL BULLETIN #51
USE OF REINFORCEMENT [2 of 2]

Units manufactured from wet cast slumpable concrete must have their reinforcement materials sufficiently rigid to prevent dislocation during the pouring process and to maintain the required cover over the reinforcement. The reinforcement must be accurately and carefully located and secured within the mold. Rebar chairs, which support the reinforcing away from the face of the mold, are not recommended with Cast Stone. Special procedures must be followed to prevent reinforcing from creating shadow lines on the face of the units when this production method is used.

Reinforcing bar sizes in panels should be kept small even where this will decrease the spacing of the bars, to resist cracking and improve temperature stress distribution. Reinforcement should be placed symmetrically to prevent warping of longer units. Typical spacing of transverse reinforcement, when required, is 12” on-center and should not exceed 18” between the bars.

One important misconception about reinforcement in concrete is that it will prevent cracking from occurring and this is simply not true. Reinforcing steel will only serve to control cracking from extending and limiting its width. No amount of conventional reinforcing will reduce the likelihood of cracking when units are designed excessively long and thin. To prevent cracking the Institute suggests that designers should consult with their manufacturers before drawing units that exceed fifteen (15) times their average effective thickness.
The technology of waterproofing masonry materials has improved considerably in the last few years and many durable water repellent materials are available which can reduce water intrusion through brick, stone and mortar joints. Proper application of waterproofing materials can be a long lasting minimizer of efflorescence, mildew, staining and dirt. Many materials are offered with 5-10 year warranties. Some studies indicate that water repellents can reduce freeze-thaw damage to masonry products and prevent loss of insulation value.

The most popular and time-tested water repellents include silicones, acrylics, silanes and siloxanes. Silicones are relatively inexpensive, only provide a surface film, and usually, only last a short time. Silicones are mainly used to keep Cast Stone clean during construction operations and they make the finished installation easy to clean. Many types of acrylics are available but most have poor vapor transmission, low penetration and inadequate resistance to ultraviolet light. Some acrylics have been known to turn yellow or produce gloss. The Cast Stone Institute® recommends the use of silane or siloxane (or blends containing each) for weatherproofing Cast Stone when a water repellents desired.

Silanes and siloxanes work by penetrating the exterior surface and then undergoing a chemical reaction with the moisture to form a water-repellent silicone resin within the void structure of the Cast Stone. Since they react with water, walls may be slightly damp but if water is contained in the pores, penetration may be limited. Do not apply the product within two days of rainfall or building washdown. Air temperature should be at least 50F for most materials and not below 40F for 24 hours.

Proper evaluation of suggested water repellents should include inspection of similar installations where the proposed material has been used under similar exposure conditions. The manufacturer or the applicator not to disfigure the Cast Stone should guarantee the application. Water repellents should be applied after all pointing, touch and repair, cleaning and inspection operations are completed.
INTRODUCTION
Sustainable design has become one of the most prominent trends in the building industry. Designers aiming for a more environmentally-friendly building design often turn to building rating systems and certification programs to help them assess the environmental impact of a building and its components. The most widely used system in the U.S. is the LEED® green building certification program.

The U.S. Green Building Council (USGBC) developed the LEED rating system; LEED stands for Leadership in Energy and Environmental Design. A separate entity, the Green Building Certification Institute (GBCI) administers LEED project certification and professional credentialing programs. The LEED certification program was developed to provide a method to define and measure what are commonly called “green buildings.” From its inception as a pilot program for new buildings in 1998 to the present, the LEED certification program has expanded and grown dramatically. There are numerous LEED rating systems organized by type of construction and end use, including:

- BD+C (Building Design and Construction): New Construction, Core & Shell, Schools, Retail, Hospitality, Data Centers, Warehouses & Distribution Centers, Healthcare
- ID+C (Interior Design and Construction): Commercial Interiors, Retail, Hospitality
- ND (Neighborhood Development): Neighborhood Development Plan, Neighborhood Development
- Homes: Homes, Mid-Rise

The most widely used rating system in the U.S. is currently LEED® BD+C: New Construction™ (LEED for New Construction) though LEED Existing Buildings: Operations and Maintenance is also widely used. While each rating system is distinct, most of the topics covered can be grouped into the same general categories. This Bulletin examines the requirements of LEED v4 for BD+C: New Construction and its relevance to cast stone.

THE USE OF CAST STONE
Cast stone is used primarily on the exterior of buildings. Cast stone veneer may be used alone or as an integral part of a clay or concrete masonry veneer. Cast stone may also be used as an accent or trim material on the exterior of buildings sheathed with other materials such as synthetic stucco. Other opportunities for use of cast stone include caps and copings on building walls and landscape walls, stair treads, and column covers. Though not as common, cast stone can also be used as pavers and in interior applications. Many of these applications can be part of a strategy to earn points in the LEED rating systems.

LEED® v4
When LEED v4 was approved in July 2013 after a lengthy revision process, it contained significant changes from the previous version (LEED 2009) particularly in the area of materials and resources. LEED v4 is organized into six environmental categories plus credits for integrated design, innovation and regional priorities. In LEED v4 the credits related to the building site and location are split into two separate categories, Sustainable Sites and Location and Transportation. Each of the six credit categories may contain mandatory prerequisites as well as voluntary credits that are worth points toward a building project’s certification. Figure 1 shows the points allocated to each category.
CERTIFICATION

Under LEED for New Construction a building project must earn at least 40 points out of a possible 110 to be a LEED-certified project. In the LEED rating systems, the more points a building project earns, the “greener” the building. The USGBC recognizes four levels of LEED certification (Figure 2).

Figure 1: LEED v4 Points by Category

Figure 2: LEED for New Construction 2009 certification levels
EARNING LEED POINTS
Cast stone masonry can make a significant contribution toward earning LEED points on a project. While no product or material alone can earn LEED points, cast stone masonry can be used as part of a strategy to earn points in many credits. It is important to remember that the calculations for these credits require inclusion of the entire building project and materials to determine the percent of qualifying material.

LOCATION AND TRANSPORATION (LT)
This category addresses issues related to the location of the project site and its connection to the surrounding community. A total of 16 points are available in this category with the majority given for locating the project in a densely developed area with a diverse array of businesses, residential areas, and services.

LT Credit 4 - Surrounding Density and Diverse Uses (1-5 points) – the intent of this credit is to encourage development in urban areas with existing infrastructure. Building products do not directly contribute to this credit. However, masonry materials are often used for urban infill development because of their appearance, size and scale, fire ratings, as well as for benefits in space required for construction. Cast stone masonry can often be installed without the use of a crane, thus helping to minimize the need for large equipment on site.

SUSTAINABLE SITES (SS)
This category addresses issues associated with site preparation as well as impacts on surrounding areas after construction is complete. A total of 10 points are available in the Sustainable Sites category. Cast stone may play a role in strategies associated with SS credit 5.

SS Credit 5: Heat Island Reduction (2 points) – the intent of this credit is to reduce the retention of heat due to dark colored surfaces by providing shade, using materials that meet solar reflectance criteria, or other strategies for the roof and non-roof areas such that their weighted area exceeds the sum of the area of site paving and total roof area. Cast stone used as caps on landscaping walls, stair treads, and pavers on the site or on the building roof can meet the criteria for earning this point.

This credit requires that paving materials have a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, materials must have an initial SR of at least 0.33 at installation. A study [Ref. 1] by the Portland Cement Association of 135 concrete specimens all had a SR of at least 0.33. One specimen made with white Portland cement had a SR of at least 0.64. Cast stone elements typically meet the LEED requirements for solar reflectance, especially if white Portland cement is used.

ENERGY & ATMOSPHERE (EA)
The Energy and Atmosphere category covers a variety of issues related to energy use associated with heating and cooling buildings including reduction in energy use, ozone reduction and use of renewable energy. There are four mandatory prerequisites and seven voluntary credits that have a total of 33 points associated with them. The thermal mass associated with cast stone and other masonry materials can help reduce the amount of energy used for heating and cooling a building. There is one prerequisite and one credit associated with this intent.

EA Prerequisite 2: Minimum Energy Performance (0 points) – as part of a masonry wall, cast stone can help mitigate temperature swings and achieve the required energy performance particularly when interior masonry is left exposed.

EA Credit 2: Optimize Energy Performance (up to 18 points) – as part of a masonry wall, cast stone can be used to help reduce the amount of energy consumed by the building. The benefit of thermal mass is best recognized when using energy modeling tools such as BLAST or EnergyPlus.
MATERIALS & RESOURCES (MR)
The intent of this category is to minimize the impact on the environment, encourage product transparency, and reduce construction waste. There are a total of 2 prerequisites and 13 points available in the Materials and Resources category. Several of the MR credits in LEED v4 are focused on specific manufacturer practices such as developing an environmental product declaration or disclosing material ingredients. As a result, achieving the credits in this category may vary widely depending upon the specific manufacturer. A brief overview of each of the MR credits is provided below.

MR Credit 1: Building Life-Cycle Impact Reduction (up to 5 points) – this credit incorporates the former Building Reuse and Material Reuse credits, and gives more weight (points) to reuse of whole buildings than the previous version of LEED. This credit contains four different paths, with the first three focused on building and material reuse and the last on new construction. Masonry buildings, many of which incorporate cast stone details, are good candidates for reuse. Cast stone features on the building interior such as columns, fireplace mantels and surrounds, stair treads, etc. are also good candidates for reuse. Anchoring details that allow for disassembly can facilitate this. Larger elements not set in mortar are especially suited for salvaging. In addition, cast stone can be repaired to conceal damage that may occur during disassembly and removal.

MR Credit 2: Building Product Disclosure and Optimization – Environmental Product Declarations (2 points), is a new credit in LEED v4. This credit has two options, worth one point each. The first option focuses on reporting of environmental impact data via an Environmental Product Declaration (EPD), while the second rewards improved performance in specified environmental impact categories through life cycle assessment. Cast stone elements produced by manufacturers having an EPD can count toward this credit.

MR Credit 3: Building Product Disclosure and Optimization – Sourcing of Raw Materials (up to 2 points) has two different options worth one point each. Option 1, Raw Material Source and Extraction Reporting, requires use of at least 20 different permanently installed products sourced from at least 5 different manufacturers that have publicly released a report from their raw material suppliers. Third-party verified corporate sustainability reports are counted in full. Self-declared reports count as only ½ value, so for example, if only self-declared reports are used, 40 products would be required instead of 20.

The second option incorporates aspects of the recycled content, rapidly renewable, certified wood and material reuse credits found in LEED 2009. Option 2, Leadership Extraction Practices, requires use of products that meet at least one of the responsible extraction criteria below for at least 25%, by cost, of the total value of permanently installed building products in the project. When calculating the value of the products, those demonstrating extended producer responsibility are valued only at 50% of their cost. Other extraction criteria are valued at the full amount.

- Extended producer responsibility
- Bio-based materials: Sustainable Agriculture Standard
- Wood products: FSC certified
- Materials reuse
- Recycled content: post consumer + ½ pre-consumer
- USGBC approved program

Cast stone elements can help earn this credit when they incorporate recycled materials into their mix, most often as aggregates or supplementary cementitious materials. Pre-consumer (post-industrial) recycled materials that may be incorporated into cast stone include recycled aggregate or slag that can be used as an aggregate, and supplementary cementitious materials like fly ash. Color may be affected by incorporation of certain recycled materials, so contacting the cast stone manufacturer is recommended.
DESIGN TIPS – TECHNICAL BULLETIN #53
CAST STONE AND LEED® v4 [5 of 6]

MR Credit 4: Building Product Disclosure and Optimization – Material Ingredients (up to 3 points) – This credit has three options worth 1 point each. All three options require documentation of the raw material ingredients for building products. Several chemical and ingredient screening programs are listed as compliance paths including the GreenScreen™ for Safer Chemicals, Cradle to Cradle certification, and the Health Product Declaration (for more information see Resources), but Material Safety Data Sheets (MSDS) are not considered compliant with this credit. Cast stone producers that provide the chemical inventory for their products using the Chemical Abstract Service Registry Numbers (CASRN) can count toward Option 1 of this credit.

MR Credit 5: Construction and Demolition Waste Management (up to 2 points) – The intent of this credit is to eliminate construction waste from landfills. Up to two points can be earned for recycling or salvaging specified amounts of construction waste, or two points can be earned if the project does not generate more than 2.5 lbs of construction waste/ft² of the building’s floor area. On-site waste from cast stone elements is limited primarily to packaging materials. Cast stone elements are carefully detailed and exact amounts are delivered to the site so that waste stone is nearly eliminated helping meet the reduction of total waste goal. Any waste cast stone elements that are present can be crushed and used as aggregate or fill.

INDOOR ENVIRONMENTAL QUALITY (IEQ)
This category aims to ensure quality indoor air among other goals. One way to achieve this is by reduction or elimination of volatile organic compounds (VOCs) in materials used in the interior of a building.

IEQ Credit 2 – Low-Emitting Materials (up to 3 points) – This credit focuses on volatile organic compound (VOC) emissions, rather than content. It also explicitly lists stone, glass, concrete, and clay brick as “…inherently non-emitting and comply without any testing if they do not include integral organic-based surface coatings, binders, or sealants.” Thus cast stone elements without integral organic-based materials used on exposed interior walls or floors meet this credit without any testing required.

SUMMARY
LEED v4 for BD+C: New Construction rating system is one of the most commonly used tools in the U.S. for assessing the impact of a building and its components on the environment. LEED covers six environmental credit categories each containing numerous credits. Cast stone, like other masonry materials, can play a role in strategies designed to achieve many of these credits, particularly in the Materials and Resources credit category.

Designers utilizing the LEED v4 for BD+C: New Construction rating system are encouraged to contact cast stone manufacturers to determine relevant practices for achieving LEED credits and to look for opportunities and the synergy that can occur when cast stone is chosen for use on a project.

REFERENCES

DESIGN TIPS – TECHNICAL BULLETIN #53
CAST STONE AND LEED® v4 [6 of 6]

WRITTEN BY
Christine A. Subasic, P.E., LEED A.P. is a consulting architectural engineer at C. Callista Subasic in Raleigh, NC, specializing in sustainable design and masonry.

Ms. Subasic has been a member of The Masonry Society (TMS) since 1992 and a member of the Board of Directors since 2002. She serves on the Architectural Practices committee, the Design Practices committee, and is a founding member of the Sustainability Committee. Ms. Subasic also represents TMS on the U.S. Green Building Council and is a member of the Green Globes ANSI Standard Development Committee.

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.

Many articles have been written over the years concerning the process used for making Cast Stone and whether the method or apparatus should be specified by the purchaser or selected by the manufacturer. Most of these articles were written by producers promoting the method(s) used at a particular facility in an attempt to promote superiority over plants using another method.

Often specifiers select one method over another, which can lead to disappointing results when their expertise may not be intrinsic to specialty concrete product manufacturing and its processes. Terminology most often used to describe a process in concrete is wet-cast, dry-cast, semi-dry, vibrant dry-tamped, vibratory dry-tamped, machine made, wet-poured, earth moist, etc. These methods can be subdivided into three basic groups according to CSI Specification 04 7200:

- “Vibrant dry tamp (dry cast) products, n—Cast Stone manufactured from earth moist, zero slump concrete densely compacted by apparatus.”
- “Wet cast products, n—Cast Stone manufactured from measurable slump concrete consolidated by apparatus.”
- “Machine casting method n—Cast Stone manufactured from earth moist, zero-slump concrete compacted by machinery using vibration and pressure against a mold until it becomes densely consolidated.”

Cast Stone units covered by a project specification should not include the manufacturing method, as the ASTM C1364 – Standard Specification for Architectural Cast Stone states that, “Slump, manufacturing method, and apparatus shall be selected by the manufacturer and not specified by the purchaser.” The project specification should cover the performance criteria (i.e. compressive strength, absorption, freeze-thaw durability) and referenced standards wherever possible, as opposed to prescriptive methods of achieving physical properties.

The designer should specify shape, color, finish and other technical and design attributes listed in the Standard Specification. For most applications, the manufacturer should submit shop drawings showing details and sizes of stones, arrangements of joints, anchor details, etc., for approval, unless the units are a standardized shape.

The manufacturer selects the design mix proportions, water-cement ratio (including slump), mold construction, apparatus for consolidating the mix into the molds and other criteria used in the manufacturing process. Factors used in determining appropriate production method(s) to be used are usually size, weight, shape, finish, type of reinforcing, anchoring methods and application in the structure.

Specifying a Cast Stone Institute Certified Plant® with the relevant CSI and ASTM Standards is your first step toward designing a successful project.

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CASE HISTORIES

On the following pages, details are shown using case histories. The typical anchoring methods shown were used on projects actually completed. All profile dimensions and anchoring methods are examples and may, in most cases, be altered to suit your particular design.

While the case histories shown in this manual demonstrate proven anchoring methods, it is beyond the scope of this publication to make specific recommendations for anchoring. Consult your structural engineer when making the particular consideration pertaining to your application.

Use of the proper type and correct quantity of anchors to fit the design and the weight of the stone will help cut the cost of both manufacturing and setting.

Planning the proper anchor for simplicity when setting stone can save time and money. Anchors and connections located in hard-to-reach areas, or connections requiring two different trades for setting may be simplified by using a different type. The cost of connections can usually be reduced by careful planning.
This project is a custom residence adjacent to a golf course in Indian Wells, California, near Palm Springs. The architects designed a contemporary Mediterranean home around a courtyard which takes full advantage of the desert climate. The colonnade on one side of the court provides a shaded walk to the entry.

Cast Stone was used extensively on the exterior of the structure. It was also used on the interior for fireplace surrounds, columns, niches and door surrounds. In the landscape, Cast Stone was used for step treads, wall cap, planters, spa coping and pool coping. The structure is wood frame and stucco with a clay tile roof. Attachment of the Cast Stone to the wood frame was accomplished using threaded inserts and metal straps nailed and/or bolted through wood blocking. All of the Cast Stone units were installed after waterproof-wrap and prior to stucco.

Access must be provided to the back side of all Cast Stone units which are bolted to the wood frame through blocking. They must, therefore, be installed prior to interior finishes.
The Cast Stone shown here is set in a full bed of mortar with the anchors fully embedded in mortar, then covered with visquene or similar plastic non-absorbent material in order to protect against cement burns during the plastering process.

In this type of construction, since the Cast Stone is not supported by brick or block as in normal masonry construction, the veneer system must be designed to carry its own weight.

Reinforcing steel is used to increase the tensile strength. Threaded inserts are cast into the stone at approximately 18 inches on center and the units usually do not exceed 4’0” in length.

Cast Stone used in wood frame and stucco applications need not be designed around brick or block coursing modules. The designer should, however, keep the Cast Stone in modular sizes which are in character with natural stone and are easily handled by the stone mason.

The designer should also consider that a minimum 1/2” of the projection of the Cast Stone will also be covered when the stucco is applied. The fascia section A would be unsuitable to cast using the Vibrant Dry Tamp method and should be reinforced with non-corrosive rebar.
DETAILS FOR ECONOMY
“L” SHAPES, “U” SHAPES AND FEATHER EDGES - PLATE #29

Moulds for manufacturing Cast Stone can be made from a wide variety of materials. The product is cast using either the Vibrant Dry Tamp or wet cast system. Regardless of the process used, a knowledge of the fundamentals of casting can benefit the building budget tremendously.

Nearly all shapes are cast face down in the mould. The mould creates five formed sides and one unformed back side. For maximum economy, the unformed side should be kept flat and left unexposed. L or U shape stones present casting problems and should be avoided whenever possible.

The coping section shown in Fig. 1 will cost more than either of the alternative sections shown due to more labor intense moulding, manufacturing, shipping and setting operations. Fig. 2 shows a header with a long vertical leg which will prohibit multiple daily castings when using the Vibrant Dry Tamp process and cause air voids in the wet cast process. Considerably less product could be packaged on a truckload using either method.

Fig. 3 illustrated the two best corner conditions; the butt joint and the quirk joint. The flat on a quirk must accommodate the largest aggregate used in the mix.
DO'S & DON'TS
DRIPS, REGLETS & SUPPORT SYSTEMS - PLATE #28

Deep drips or drips with no draft serve no better purpose than the three drips shown in Fig. 4. Frail drips can shear the edge of the stone when subjected to freezing rain. When using the quarter round type drip, build enough projection into the design to allow a 1” extension beyond the drip. The “V” and half round types are simpler to manufacture, can be placed closer to the edge, work just as well and can endure more abuse.

Seven (7) degrees minimum draft on formed flashing and anchor slots is required in order to ensure crisp, straight grooves. Metal reglets can be cast into the formed sides of stones when structural reasons dictate that a dovetails be used (Fig. 5).

Relieving angles are by far the most economical method of supporting Cast Stone. Round or bar stock can be welded to the angle to receive anchor slots in the stone as shown in Fig. 6. Narrow noses used to disguise angles are subject to breakage during handling and are difficult to repair.

Avoid weld plates and bolts projecting from the backs of stones (Fig. 7). Dowel holes in ends can be used for alignment and for tying back through eyebolts connected to the backup. Threaded inserts are more costly and must be pinpointed both vertically and horizontally.

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DO'S & DON'TS
DRAFT, SUPPORT SYSTEMS & RADIUS PIECES - PLATE #26

Fig. 8. Projecting portions of sections, in general, should not exceed their thickness. A 7 to 9 degree draft is usually needed to separate the production pieces from the mould and may be provided by the manufacturer even where 90 degrees is shown on the drawings.

The intersection of the unexposed or back side with the formed sides should not come to a feather edge in the mould. This can be avoided by using a shoulder as shown in Fig. 9.

The preferred section shown in Fig. 10 can be efficiently produced from a one-piece face pattern. The alternative section must be drawn across a multi-piece pattern after each casting due to no mould draft, resulting in higher costs and compromised quality.

Use standard building stone anchors as shown on page 82 whenever possible. Where relieving angles cannot be positioned to carry the load, threaded or adjustable inserts can be employed (Fig. 11).

Allow enough space in the masonry wythe to make curved pieces straight on the back. This need not apply to coping and similar sections where the major unexposed side is flat at the masonry bed joint.
WINDBOW SILLS

TYPICAL LUG AND SLIP SILLS - PLATE #7 [1 of 2]

The details on the following sheet explain that brick coursing tables should be used to determine heights of sills in order to eliminate costly field adjustments of surrounding bricks.

When determining the height of Cast Stone:

A. The bottom of the sill to the bottom of the lintel must always equal brick coursing.

B. The lintel height (if stone) equals brick coursing minus one joint.

C. The sill height equals brick coursing to the bottom of the lintel, minus the overall window dimension.

D. The height of the lug must equal brick coursing minus one joint.

Lug sills are sills that project into the brickwork at either side of the masonry opening. This projection is generally in lengths corresponding to a full or half brick length. Lug sills must be set in place prior to any masonry work surrounding the opening since the masonry rests on the sill lug. All lug sills are recommended to be jointed, regardless of length, due to loading on the lug ends.

Slip sills have no lug and the lengths are figured 1/2” less than the brick masonry opening (for a 1/4” mortar joint) or 3/4” less where sealant is desired to provide a 3/8” joint for gun-in of sealant. The advantage of slip sills is that they may be set in place after all masonry work has been completed, therefore minimizing potential damage during construction.

Drips are provided on sills where 1”+ projections occur, to stop water from returning to the wall. Drips are terminated 1/2” from the edge of the masonry opening where the end of the sill is exposed to view.
WINDOW SILLS
TYPICAL LUG AND SLIP SILLS - PLATE #7 [2 of 2]

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MISC. COLUMN DETAILS - PLATE #27

Allowance for draft and feather edges in the production mould represent careful considerations which are made by the manufacturer. In most instances these accommodations have no effect on the design but deliver a major effect on the quality of the casting. Your Cast Stone Institute producer member pays a great deal of attention to these details.

Columns are usually manufactured solid. Often, U-shaped column covers are attached to structural steel. This removes the stone columns from the critical construction schedule path and prevents the columns from damage during construction.

Anchorage of columns and column covers is accomplished with dowel pins connecting units together, combining with standard anchors as shown on page 82 for tying back to the structure.

Vertical jointing of column covers can be made straight down each side or staggered from side to side.
PARAPET COPING
CONTROL JOINT DETAILS - PLATE #17

When installed properly, Cast Stone coping is the best type of moisture protection for a masonry wall. Coping provides aesthetic treatment, bonds with the masonry and its relatively maintenance-free.

Coping should be thoroughly drenched with clear, potable water and then set in a full bed of mortar with the bed joint raked back 1/2” for gun-in of sealant. Head joints are left open to receive properly placed backer rod, primer and sealant. The backer rod should be placed parallel to the wash of the coping.

Bridge coping over control joints to maximize their effectiveness and use an elastic joint as shown. All coping should have a minimum 1/2” wash to control water runoff.

For maximum economy, either maintain consistent spacing between control joints to permit modularity in lengths of masonry bound stones or allow a special length stone at each control joint.

Where 1”+ projections occur, drips should be provided to break the return of water to the wall. See page 50 for different types of drips.

CONTROL JOINTS
For optimum economy with trim stones, maintain the maximum quantity of lengths at the same size; use a short or long piece to control joints as shown:

Bridge coping over control joints. Set the long bridge section in a full bed of mortar, and dowel the stone as shown. Set the short bridge section on elastomeric sealant to provide for movement. Provide end type dowel holes in thin coping or on raked walls to allow for added security as necessary. Gun sealant into dowel hole in lieu of mortar.
FLASHING AND BOND
PARAPET COPING DETAILS - PLATE #18

When flashing is used below parapet coping, steps must be taken to maintain the masonry bond with the well below. It is a mistake to employ metal flashing fully between the coping and the wall. This type of moisture barrier creates a ponding effect which may allow the stone to deteriorate when the parapet is subjected to freezing and thawing. Through-wall type flashing should be used as shown on below. This allows the coping to wick and drain to the weep holes below while maintaining the masonry bond with the wall.

Where non-masonry backup wall systems are used, metal lath should be attached to the backup to span the wall continuously so that mortar may be used to bond the coping to the wall.

Flashing grooves can be cast into the tops of stones as shown on page 50 where dovetail reglets are required, galvanished metal units can be cast into a formed side of the stone, kept sufficiently away from the edge.

Cramp anchors or end dowels may be used for anchoring coping together and are less costly to install than bottom dowels which must be tediously located and sealed or capped when used in conjunction with flashing.
METAL STUD WALL SYSTEMS
WATERTABLE, SILL, HEADER, & COPING WITH METAL STUD WALL SYSTEM - PLATE #9

Details of anchoring with metal stud wall systems can usually be derived from the conventional methods after special attention is given to the structural considerations of this type of wall system.

Anchors tie the veneer to the backup; they must be stiff enough to resist tension and compression, but flexible enough to not resist shear. This flexibility permits in-plane differential movements between the backup and the veneer which are essential to the wall system. Lateral loads are shared by both the veneer and the backup. Therefore, corrugated metal brick ties should never be used in connecting the veneer wall to metal studs.

There should be a minimum of two anchor straps per stone and sufficient brick ties in accordance with the recommendations of your Engineer. The Brick Institute of America suggests one brick tie for each 2-2/3 sq. foot of wall area to tie back plain veneer.

Sheathing must be securely attached to both sides of the studs. Sheathing must be rigid and properly attached for it to be effective.
QUOINS

RUSTICATION, CHAMFER & SMOOTH WITH MASONRY, STEEL & CONCRETE BACKUP - PLATE #8

Three different types of quoins are shown: rusticated, chamfered and smooth. They are shown attached to various types of backup.

Quoins should be sized in length to match the running bond of the brickwork and must match brick coursing in height, minus one joint.

Two anchor slots are provided in the top and bottom of these stones to receive ashlar anchor strap #5 shown on page C3. Alternatively, a continuous anchor slot may be used instead. This eliminates the need to pinpoint anchor locations in the field – a common source of confusion and delay.

The cost of each type of quoin shown here may be approximately the same per cubic foot. The amount of time required to place a chamfer or rustication in the mould is almost negligible, due to the amount of repetition intrinsic to this type of work.

Labor costs are substantially reduced by large quantities of typical pieces.
Normally the unformed or back side of Cast Stone is made with a trowel or float finish. Special care and considerable time is needed to produce an unformed side which resembles the finish on the front face.

The clear span of the sunshade spandrels would have been impossible to reinforce in natural stone. By combining the compressive strength of concrete with the tensile strength of steel, Cast Stone can deliver the beauty of natural stone with the structural advantages of precast concrete.

A wood-filled dovetail was cast into the seat of the sill to allow for fastening of the windows without the need to pinpoint fastener locations on the shop drawings.

Dowel holes in the bottom of the plaster panels were used in conjunction with slots cast into the tops of the sills to allow horizontal adjustment during setting.

A slight taper (draft) on the inside of the window sill lugs was needed to allow the sill to part from the production mould during casting.
Park Cities Baptist Church was originally constructed in 1956. The original design was Georgian, with red brick and white Cast Stone; so in 1988 when the Ruth Collins Music and Education Building was ready to break ground, materials had already been selected.

The economy of Cast Stone does not lend itself just to new structures. When future additions are required, the Cast Stone is readily available to match the existing work. Full length pieces are often salvaged from the original structure and used as models for moulds. Such was the case at Park Cities.

The Ruth Collins Music and Educational Building Addition contains 360 quoin pieces, 765 lineal feet of base and watertable, 673 lf of belt, 614 lf of architrave, 906 lf of dentiled cornice and coping, 14 each 2/3 entasis column covers, 12 rosettes and sundry quantities of window surrounds, door surrounds, finials, keystones and ashlar pieces; all totalling over 8500 cubic feet.

The present Church takes up 3 city blocks.
The following are sections showing the cornice, watertable, architrave, belt course and quoins. Note that all sections are designed with flat backs for economy.

Bolts and plates are used to anchor cornice stones with heavy projections. Non-corrosive bent anchor bolts are grouted into the masonry bond beam and final torque applied to the bolts after setting.

This same method may be adapted to concrete structures or to a steel frame by hooking and welding the bent anchor bolt or rod under a beam flange.

Anchor straps used here are 1/8” x 1” (typically) non-corrosive metal stone anchors and may be galvanished or stainless steel, Type 302 or 304.
PROJECT: PARK CITIES BAPTIST CHURCH  
ARCHITECT: F&S PARTNERS, INC.  
DALLAS, TX - PLATE #3

As with nearly any custom product which requires initial tooling prior to fabrication, a great deal of economy can be achieved by taking advantage of repetition.

Note the way the architect has logically re-used the bottom portions of sections A & B employed on the North elevation (Plate #1) and carried the profile through to another use on the South elevation (Plate #3).

Careful consideration of the effects of brick coursing has afforded the Owner a considerable cost savings in this example.
Models of ornament can be provided either by Cast Stone manufacturer, the Architect or the Owner’s Representative.

Models can consist of almost any material, including existing stones. Plaster of Paris makes an ideal model and there are a large number of ornamental plasters servicing the industry for this purpose.

Lintels may be reinforced and made to bear on the wall or they may be supported by a shelf angle from either below or above the stone, as shown in window surround section F.

Threaded inserts are more costly than dowel holes or anchor slots, particularly when required in the unformed (or back) side of the stone.
The new Visitors Entrance at the White House looks like a limestone Palladian garden pavilion with tall French windows separated by Jeffersonian columns and ashlar pier blocks.

Built in 1983, the new security building houses the magnetometer which are used to check as many as 8,000 visitors per day.

The pavilion is situated directly opposite the Department of the Treasury Building on East Executive Drive and is built into a heavily planted earth berm so that it is visible only from the street.

The building is clad entirely with Cast Stone selected to match the limestone facade of the Treasury Building and consists of ashlar blocks, pilaster blocks, columns and a band of stone completely encircling the roof line comprising the frieze, cornice, parapet and coping.
PROJECT: THE WHITE HOUSE VISITORS ENTRANCE  
ARCHITECT: WILEY & WILSON  
WASHINGTON, D.C - PLATE #15

The details shown on these pages were chosen for monumental security and infinite longevity. The types of connections shown are intended to illustrate the anchoring methods used for this purpose.

Stainless steel weld plates were embedded into the backs and tops of stones. The pieces were reinforced with epoxy coated grade 60 rebar; an impossible task for natural cut stone. Alternative anchoring methods using the standard building stone anchors shown in the next section may be employed for greater economy.

Weld plates must be specially fabricated, are difficult to position on the unformed side of pieces manufactured with the Vibrant Dry Tamp method and usually require two different trades for setting the stone.
Details of the methods used to anchor the parapet are shown here. Stainless steel relieving angles are attached to the concrete structure with non-corrosive bolts. Each stone joint is used to carry a portion of the load.

Nelson studs are electro-welded to the stainless steel plates and then are clamped to the side of the mould at time of casting.

When designing an anchoring system with embedded hardware, allowance must be made for both horizontal and vertical adjustment. Note the freedom allowed to the stonemason when placing the frieze and parapet, but the potential exists for problems to be encountered due to lack of vertical adjustment at the top of the cornice. If the concrete runs above the line of the cornice, an angle must be welded to the plate for an alternative connection from above.
Cast Stone columns are jointed in an odd number of segments. The base, shaft and capital of this free-standing column are shown on this detail page.

Alternatively, the shaft may be jointed at third points along its length or it may be split, as shown on page 16, to create a set of column covers.

The key and pocket arrangement shown on the detail section through the capital may be exchanged for dowel holes and stainless steel (Type 302 or 304) pins if desired.

Dowel holes and anchor slots should always be completely filled with mortar.
The curvature of the shaft follows the classical “Golden Rule” taper of 1/3 straight, 2/3 entasis as shown on this detail plate.

Master modelmakers lay out the full-size profile of columns on sheet metal which is then cut to form a template. The template is fastened to a shoe, or running board to create a running mould against which a wet plaster drum is rotated until the finished model is created. After curing, the model is sealed and is used to form the master mould.

The sealed model is then used as the positive form in the moulding process. The mould can be made from Plaster of Paris, concrete, glass-fiber-reinforced plastic, urethane, wood or even metal, depending upon the total number of casts required and the surface texture desired.
The sanctuary and classroom buildings of St. Joseph’s Catholic Church were meticulously planned by the architects and the pastor. An existing educational building was constructed several years prior and has a buff precast concrete exterior.

The pastor was educated in Italy where the cathedrals of Orieto and Sicena are situated. These structures are well known for their exterior (and interior) contrasting horizontal stone banding. The pastor required the architect to carry this theme to the new sanctuary.

The architect selected a buff brick and contrasted it throughout the entire interior and exterior of the building with a 1’4” high horizontal white Cast Stone banding. Cast Stone was also used as window sills, parapet coping, bell tower coping, headers, window surrounds, altar trim and sundry trim. The use of light buff brick and white Cast Stone tied the pastor’s theme into the existing structure and solved the architect’s dilemma.
The Executive Hills Bridges Project is located in a highly visible and restricted residential development in Kansas City, Missouri. The developer’s objective was to design a Cast Stone balustrade for the bridge which would match the traditional style and elegance of the homes within the estates. The buff limestone balustrade is visible from either side of the bridge.

The cost savings realized by the developer was substantial because the designer accomplished the entire 450 ft. balustrade using only eight different piece types.

Stainless steel dowel pins are used to anchor the post bases and bottom rail to the concrete slab for connecting the four sides’ panels together and to the post base. Anchor straps are used for tying the panels together at the top and dowels are used to accomplish the balance of the connections. A 1/2” stainless steel Type 302 dowel pin fits a 3/4” x 2” dowel hole filled completely with mortar during setting (refer to specification section). A 1/2” threaded stainless steel rod runs through the baluster for doweling and reinforcement.
This rose window on the sanctuary is a reproduction of a window in Europe which is over two hundred years old. The Chairman of the Building Committee presented a photograph to the architect, who in turn commissioned his local Cast Stone manufacturer.

The manufacturer was provided with the diameter and depth of the required window and from this information projected each section and ornament to full size scale.

Clay and plaster models representing one segment were submitted for approval before the moulds were produced. Note how the pieces were segmented to achieve flat backs for economy, maximum repetition from each mould and allowance for sandwiching of the stained glass.

In spite of the high use of ornament in the design, the repetition available to each mould made it possible to produce two Cast Stone window units in a small fraction of the time, and at a small fraction of the cost of cut stone.
PROJECT: EMPIRE DISTRICT ELECTRIC HEADQUARTERS
ARCHITECT: BLACK & VEATCH
JOPLIN, MO - PLATE #23

The architect’s objective was to design a masonry office building as economically as possible with a brick and stone veneer and metal stud wall backup.

The manufacturer provided Cast Stone belt courses, sills, watertable, keystone and a massive entry arch (not shown) in a special grey color to contrast with the common red and orange brick, resulting in a 25% cost savings over other materials while creating the maximum design look.

All trim pieces were anchored with 1/4” stainless steel rods (see page 81 for anchor details). The massive arches contained 1-1/4” sleeves precast into the stone to receive 1” rebar. The sleeves were then epoxy injected.

Continuous anchor slots cast in the sides of the stone allow for anchoring without the need to pinpoint locations in the field or on the shop drawings.
The Cast Stone and brick signs at The Fountains Shopping Mall in Plantations, Florida were an after-thought to the project. Instead of using contrasting materials for project identification, the materials utilized on the buildings were employed for the signs: buff-grey Cast Stone and brown brick.

The design lends itself to Cast Stone treatment because there was more than one sign required. The attachment of brass lettering to the Cast Stone banding not only created a highly visual element, but it also carried the refined architectural treatment from the buildings to the street.
The design of the expansion to the women’s jail was dictated by the existing structure. Cast Stone was chosen for its ability to precisely match the color, texture and profile of the existing work.

Cast Stone provided both a dignified trim medium and a perfect location for embedding weld plates and inserts to receive security equipment.

The “saw tooth” design of the panels provided an interesting and rigged touch to the mass of the brick structure. During the morning and late afternoon hours, the shadow effect from the sun created by these projections enhanced the effect.
PROJECT: THE ALHAMBRA HYATT HOTEL  
ARCHITECT: NICHOLS ASSOCIATES  
CORAL GABLES, FLA - PLATE #24

In keeping with the architectural style of the community, the developers of this large hotel and office complex desired to enhance the buildings with natural cut stone veneer, columns, balustrade and trim which is locally called “Florida Keystone.”

The procurement of the native natural stone, cut to the shapes as shown on the architectural drawings, proved to be prohibitively expensive. Cast Stone adapted to cost-cutting measures and was the selection used by the architect to achieve the beauty of natural stone with the structural and long-term advantages on concrete.

Maintenance of the project schedule was another major consideration; the attainment of the desired occupancy dates would have been impossible to achieve if the natural stone had been used.

Cast Stone was accepted as an alternate bid to the native material and the acceptance of this approach solved the design problem and allowed this landmark structure to be completed in record time while allowing the project to blend with its historic surroundings.
The details shown are used where Cast Stone is employed on stucco buildings where freeze-thaw is not a factor in building design.

Accordingly, this type of veneer can be made in thicknesses as thin as 1”, depending upon the size of each unit, the finish desired, whether reinforcing is required and the manufacturing method used. Consult with your producer before specifying thicknesses less then 2”. Rustication can be provided to accent features and add relatively no cost to the units.

On this stucco finished building application, 1”x1/8” aluminum straps were used to tie back the Cast Stone to the supporting structure. A full wet mortar backing is used and the joints are grouted to match the color of the stone. The final stucco finish on the building permanently covers the anchoring.

Aluminum is used due to ease of fabrication, the relatively light weight of the units and minimal corrosion possibility when used in cementitious embedding with coupled metals at the air-concrete interface and under plaster. Stainless steel or galvanized steel anchor straps should always be used with typical masonry applications.
## STONE DIMENSIONS

(Course Dimension less 3/8" joint)

<table>
<thead>
<tr>
<th>COURSE</th>
<th>Stone Coursing with Brick</th>
<th>Stone Coursing with Concrete Block</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Modular Brick</td>
<td>2 5/8&quot; Brick</td>
</tr>
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<td>1</td>
<td>2 1/4&quot;</td>
<td>2 5/8&quot;</td>
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<td>2</td>
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</tbody>
</table>

Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
BUILDING STONE ANCHORS
ANCHORS - PLATE #32

Standard masonry anchors are preferred over embedded hardware for use with Cast Stone. They are reliable, time-tested, and commercially available, need not be specially fabricated and afford great flexibility in meeting jobsite conditions.

Non-corrosive type anchors should be used for all anchoring. Stainless steel Type 302 or 304 are the standard type used in this class of work.

Typical sizes shown are 1/8” x 1” straps, 1/4” rods and 1/2” dowels. Dowel holes for 1/2” or 3/4” dowels are usually 1” diameter filled completely with mortar during setting. Anchor slots are typically 3/4” wide and similarly are filled with mortar.

Typical details are not universal. The Cast Stone Institute® strongly recommends that designers consult with the project engineer and Cast Stone Institute® producer member in the early stages of design to determine the appropriate anchoring strategy.
BUILDING STONE ANCHORS

STANDARD INSERTS

Cast Iron Wedge Insert
Supports weight of the Stone when there is no supporting masonry or steel below.

Threaded Loop Insert
Used where adjustment is not required.

Cast Iron Wedge Insert
Same as above, but used primarily for thin panels.

Threaded Insert
Similar to above, but used for thin sections.

Cast Iron Adjustable Insert
Used to stabilize Stone which is otherwise supported. Allows for horizontal adjustment. Can also be used to hang soffit stones.

PVC Reglet
Used where attachment of flashing is required. Primarily for vertical surfaces.

Non-Ferrous Threaded Insert
Used in non-loadbearing applications.

Galvanized Dove Tail Reglet
Used for attachment of flashing. Most economical type of reglet. Also used for anchoring to concrete structures.

Engineering information is available upon request.
**TOLERANCES**

Tolerances dimensional tolerances for Cast Stone are the numerically greater of plus or minus 1/8” or length/360. This applies to all sectional dimensions: length, twist, square and camber.

Dowel hole and insert locations in the formed sides of pieces can be cast fairly accurately, within 1/8”. Additional tolerance, totaling 3/8”, must be allowed when they are located in the back or unformed side.

When assessing individual stones for tolerance, the setting tolerances of plus or minus 1/8” (allowable out of plane from adjacent unit) must also be taken into consideration as shown. This tolerance also applies to flashing grooves, false joints and similar reliefs.
GLOSSARY OF TERMINOLOGY [1 of 4]

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSORPTION</td>
<td>Percentage of moisture absorption by weight after immersion in water.</td>
</tr>
<tr>
<td>ACID ETCHING</td>
<td>Process of applying a solution of hydrochloric or muriatic acid and water to the exposed surface of Cast Stone in order to remove the cement film from the aggregates, achieving a fine-grained finish which simulates natural cut stone.</td>
</tr>
<tr>
<td>ADMIXTURES</td>
<td>Chemicals used to improve the physical properties of Cast Stone.</td>
</tr>
<tr>
<td>AIR CONTENT</td>
<td>The amount of entrained air in wet cast units.</td>
</tr>
<tr>
<td>AIR-ENTRAINING ADMIXTURES</td>
<td>Chemicals used to develop entrained air in wet cast units.</td>
</tr>
<tr>
<td>AIR VOIDS</td>
<td>Surface imperfections with restricted size and occurrences in cast stone units.</td>
</tr>
<tr>
<td>ANCHOR</td>
<td>Metal device used for securing Cast Stone to a rigid structure.</td>
</tr>
<tr>
<td>ARCHITRAVE</td>
<td>The bottom portion of an entablature bearing on the column capitals and supporting frieze.</td>
</tr>
<tr>
<td>ARRIS</td>
<td>Angle, corner, or edge of a Cast Stone unit.</td>
</tr>
<tr>
<td>ASHLAR</td>
<td>Flat units square or rectangle in size, bonded and laid in mortar.</td>
</tr>
<tr>
<td>BACKUP MIX</td>
<td>Concrete, normally composed of concrete, sand, gravel, and grey cement; used for the unexposed portion of Cast Stone.</td>
</tr>
<tr>
<td>BALUSTER</td>
<td>A small column or other vertical shape when placed in a series constitutes a miniature colonnade which is called a balustrade.</td>
</tr>
<tr>
<td>BAND COURSE</td>
<td>See Belt Course</td>
</tr>
<tr>
<td>BASE COURSE</td>
<td>Continuous horizontal course that sets on the brick ledge. It is the first course set in a wall.</td>
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<tr>
<td>BED JOINT</td>
<td>The joint, which the stone sets on. It is normally filled with mortar or backer rod and sealant.</td>
</tr>
<tr>
<td>BELT COURSE</td>
<td>Continuous horizontal course of Cast Stone incorporated in a wall above the base course and below the frieze.</td>
</tr>
<tr>
<td>BEVEL</td>
<td>See Chamfer</td>
</tr>
<tr>
<td>BUGHOLE</td>
<td>An unacceptable air void in a finished surface.</td>
</tr>
<tr>
<td>BULL NOSE</td>
<td>Convex molding which usually starts at the top of the Cast Stone unit and returns to the predominant face.</td>
</tr>
<tr>
<td>CAPITAL</td>
<td>Uppermost member of a column or a pilaster crowning the shaft.</td>
</tr>
<tr>
<td>CAST STONE</td>
<td>A refined architectural concrete building unit manufactured to simulate natural cut stone, used in unit masonry applications.</td>
</tr>
<tr>
<td>COARSE AGGREGATE</td>
<td>Aggregate predominately retained on the No. 4 (4.74-mm) sieve.</td>
</tr>
<tr>
<td>COATED REBAR</td>
<td>Rebar coated with a zinc alloy or epoxy. This rebar is normally used when rebar placement is within 1-1/2 inches from an exposed face.</td>
</tr>
<tr>
<td>CHAIN</td>
<td>A stack of quoins.</td>
</tr>
<tr>
<td>CHAMFER</td>
<td>Slanted surface which connects two external surfaces forming two arises.</td>
</tr>
<tr>
<td>COLORING</td>
<td>The process of (or material used for) tinting the hue of Cast Stone. It is normally achieved through the use of aggregates or inorganic iron oxide pigments.</td>
</tr>
<tr>
<td>COLUMN</td>
<td>Supporting pillar, usually consisting of a round shaft, a capital and a base.</td>
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<tr>
<td>COPING</td>
<td>Stone unit used to cap off the top of a wall. Its function is to protect the wall from the natural elements as well as adding an aesthetic value to the wall.</td>
</tr>
</tbody>
</table>
GLOSSARY OF TERMINOLOGY [2 of 4]

CORNICE  Molded piece at the top of an entablature projected with an ogee profile at the top leading edge with other relieves below.

COURSE  Horizontal scope of units incorporated in a wall.

CRAMP  "U" shaped metal anchors used to attach two abutting units.

CRAZING  A series of hairline cracks, normally less than a thirty-second of an inch in depth in the outer surface of a concrete product. Crazing does not constitute cause for rejection of Cast Stone.

CURING  The process of hydrating the Portland Cement in Cast Stone to a specified age or compressive strength in a warm, moist environment.

CUT STONE  Natural stone quarried and dressed to an architectural shape.

DENTIL  Block projections of an entablature below the cornice course.

DOWEL  Round (usually non-corrosive) metal pin used in anchoring and aligning Cast Stone.

DRIP  Continuous groove cut or cast into the bottom of the projecting edge of Cast Stone in order to disrupt the capillary attraction of water to the wall below.

DRY CAST CONCRETE  Manufactured from zero slump concrete. See Vibrant Dry Tamp Concrete

EDGING  The hand tooling of the arris.

EFFLORESCENCE  Visually observable signs of saline discharge onto a portion of a masonry wall.

ENTABLATURE  Incorporates an architrave, frieze, and cornice.

ENTASIS  The portion of a classic column, which has a diminishing arc on the shaft. The lower third of the column is straight (two-thirds entasis column).

ERECPTION  Setting of large stones usually with a crane.

EXTRADOS  The outer portion of an arch.

FACE  The exposed portion of Cast Stone after it is installed.

FACING  Mix Materials used for the portion of Cast Stone, which is exposed to view after installed.

FASCIA  A broad and well-defined continuous horizontal band of Cast Stone at least header high.

FINE AGGREGATE  That portion of the aggregates passing the 4.75-mm (No. 4) sieve and retained on the No. 200 (75-µm) sieve.

FEATHER EDGE  A thin edge with an arris considerably less than ninety degrees. It is so named because of its frailty when handled (see quirk miter).

FILLET  Continuous raised lug at the top back edge of a window sill. It serves as a moisture barrier and as the color a seat for the window sash.

FINES  Aggregate passing a #4 sieve.

FINISH  Final exposed surface of Cast Stone. It is independent of color, but it will control the color intensity. Acid etching is the most popular Cast Stone finish.

FORM  See mold.

FRIEZE  Flat unit of an entablature located between the architrave and cornice.

FULL BED  A horizontal joint completely filled with mortar.

GROUT  Mortar of pouring consistency.

HEADER  Stone unit running horizontally over an opening in a wall. Nor self supporting (see lintel).

INSERT  A metal device cast into a unit normally used for anchoring or handling.

INCISE  To cast concave or engrave.
## GLOSSARY OF TERMINOLOGY [3 of 4]

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>INSCRIPTION</td>
<td>Characters incised into a unit.</td>
</tr>
<tr>
<td>INTRADOS</td>
<td>The inner portion of an arch.</td>
</tr>
<tr>
<td>JAMB</td>
<td>The vertical unit running up the side of an opening.</td>
</tr>
<tr>
<td>JOINT</td>
<td>Gap between masonry units filled with mortar or backer rod and sealant.</td>
</tr>
<tr>
<td>JOINTING SCHEME</td>
<td>The jointing pattern shown on contract documents.</td>
</tr>
<tr>
<td>KEYSTONE</td>
<td>The unit at the center of an arch. It is generally wedge shaped when viewed</td>
</tr>
<tr>
<td></td>
<td>in elevation.</td>
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<tr>
<td>LIFT HOOK</td>
<td>A metal device embedded into the Cast Stone for the purpose of lifting</td>
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<td></td>
<td>and/or anchoring.</td>
</tr>
<tr>
<td>LINTEL</td>
<td>A unit spanning an opening and carrying the load of a wall above.</td>
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<tr>
<td>LUG</td>
<td>The portion of a Cast Stone unit running beyond an opening horizontally</td>
</tr>
<tr>
<td></td>
<td>into a wall.</td>
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<tr>
<td>LUG SILL</td>
<td>Windowsill built into the wall, which runs horizontally beyond the</td>
</tr>
<tr>
<td></td>
<td>masonry opening.</td>
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<tr>
<td>MASONERY</td>
<td>Construction made by the laying of units of substantial material such as</td>
</tr>
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<td></td>
<td>brick, block and Cast Stone.</td>
</tr>
<tr>
<td>MİTER</td>
<td>The splicing of two Cast Stone profiles at an angle (see quirk).</td>
</tr>
<tr>
<td>MEDALLION</td>
<td>An ornamental block.</td>
</tr>
<tr>
<td>MODEL</td>
<td>The positive shape that represents the final product. A mold is formed</td>
</tr>
<tr>
<td></td>
<td>around a model.</td>
</tr>
<tr>
<td>MODİLLİON</td>
<td>Ornamental block located under the corona of a cornice.</td>
</tr>
<tr>
<td>MOLDING</td>
<td>Any linear plane, which deviates from a flat surface.</td>
</tr>
<tr>
<td>MORTAR</td>
<td>A blend of cement, lime, sand, and water which is applied at a pliable</td>
</tr>
<tr>
<td></td>
<td>consistency to bond masonry units.</td>
</tr>
<tr>
<td>MOLD</td>
<td>A form in which Cast Stone is shaped. It can be constructed from wood,</td>
</tr>
<tr>
<td></td>
<td>plaster, rubber, fiberglass, and other materials.</td>
</tr>
<tr>
<td>MULLION</td>
<td>A vertical member, which forms a separation from adjacent window or door</td>
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<tr>
<td></td>
<td>frames.</td>
</tr>
<tr>
<td>POINTİNG</td>
<td>See Tuck Pointing</td>
</tr>
<tr>
<td>PRECAST</td>
<td>A concrete product not poured in place.</td>
</tr>
<tr>
<td>QUIRK MİTER</td>
<td>An end condition cast with a forty-five degree angle and an edge put on</td>
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<tr>
<td></td>
<td>the point at a ninety degree angle to eliminate feather edging.</td>
</tr>
<tr>
<td>QUOİN</td>
<td>Cast Stone block used to make up a corner of a wall.</td>
</tr>
<tr>
<td>RECESS</td>
<td>A depression in a flat surface.</td>
</tr>
<tr>
<td>REGLET</td>
<td>A continuous groove cast or cut into a Cast Stone unit to receive</td>
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<tr>
<td></td>
<td>flashing.</td>
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<tr>
<td>REİNCERİNG</td>
<td>Rebar placed into a Cast Stone unit during the manufacturing process to</td>
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<td></td>
<td>augment the unit during handling or to enable it to carry a structural</td>
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<td></td>
<td>load (i.e. lintel).</td>
</tr>
<tr>
<td>REİBAR</td>
<td>A deformed steel unit used for reinforcing Cast Stone.</td>
</tr>
<tr>
<td>RELİEF</td>
<td>Ornamentation.</td>
</tr>
<tr>
<td>REPRİSE</td>
<td>An internal corner of a profiled unit.</td>
</tr>
<tr>
<td>RETURN</td>
<td>An external corner of a profiled unit.</td>
</tr>
<tr>
<td>REVEAL</td>
<td>The side of an opening (as for a window) between a frame and the outer</td>
</tr>
<tr>
<td></td>
<td>surface of a wall.</td>
</tr>
<tr>
<td>RUSTİCATİON</td>
<td>An incision cast around the outer edges of a unit to produce a shaded</td>
</tr>
<tr>
<td></td>
<td>affect.</td>
</tr>
<tr>
<td>SAMPLE</td>
<td>The specimen submitted to represent the color and texture of Cast Stone.</td>
</tr>
<tr>
<td></td>
<td>This specimen dictates the general range of the color and texture of</td>
</tr>
<tr>
<td></td>
<td>production pieces.</td>
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</tbody>
</table>

This Technical Bulletin is provided by the Cast Stone Institute®, and is intended for guidance only. Specific details should be obtained from the manufacturer or supplier of the Cast Stone units.
GLOSSARY OF TERMINOLOGY [4 of 4]

SETTING  The mason’s process of installing and anchoring Cast Stone.

SETTING PADS  Non-corrosive pads used to set Cast Stone on in order to prevent the bed joint from compressing at the time of setting.

SETTING DRAWING  Drawing which the Cast Stone manufacturer submits for approval detailing all aspects of the installation with piece markings and final locations of stones.

SHOP DRAWING  The drawing, which the Cast Stone manufacturer submits for approval showing size and shape of pieces, exposed faces, jointing, anchoring, reinforcing and unit cross section.

SLIP SILL  A Cast Stone windowsill that fits within the masonry opening.

SOFIT  The exposed underside portion of a unit.

SPANDREL  A unit spanning an opening with bearing beyond the opening. It is not normally load bearing, but supporting.

SPRINGER  A unit that is located at the spring line of an arch.

SURROUND  An encasement of an opening.

TEMPLATE  A type of model used to convey the pattern, shape, or profile to be used by the manufacturer in the molding process.

TEXTURE  The finish structure consisting of visual and tactile surface qualities.

TOLERANCE  Allowable deviation from specified dimensions.

TRACERY  Arched ornamental work with interlacing, branching lines. Usually consists of openwork in the head of a Gothic window.

TOOLED FINISH  A finish obtained by texturing either the mold or the Cast Stone (ex. bushhammered, six-cut).

TROWEL FINISH  A finish normally given to the back or unformed side of Cast Stone. This finish may look slightly different than the molded sides of the piece.

TUCK POINTING  The final tooling or pointing of a raked out mortar joint.

VIBRANT DRY TAMP  Vibratory ramming of earth moist, zero-slump concrete against a rigid mold until it is densely compacted.

VOLUTE  The scroll shaped ornament forming the chief feature on an Ionic capital.

WARP  Twist or bowing of final casting measured by deviation from plane and tolerance.

WASH  A sloping horizontal surface formed to cause water to run off.

WATER REPELLENT  Normally a clear sealer sprayed or brushed on the exposed portion of a masonry wall to deflect moisture.

WATERTABLE  The course of Cast Stone that sits on the base course. This course normally transcends an offset in the building.

WEEP-HOLE  An opening normally in a masonry head joint at the bottom of a unit to allow any moisture behind it to escape.

WELD PLATE  A square metal device cast flush to the surface for attachment by means of welding.

WET CAST CONCRETE  Manufactured from measurable slump concrete.