

## USE OF REINFORCEMENT

One advantage of cast stone over natural stone is its ability to contain reinforcement. This gives cast stone an advantage by combining the high compressive strength of the cast stone with the flexural strength of reinforcement to provide additional stability and crack control. But despite this advantage, cast stone is an architectural element and should not be used to support the building structure or as a load bearing element.

It is important to understand that not all cast stone units require reinforcement in their design. Cast stone applications such as replacement for natural stone, manufactured masonry units and other non-structural applications that include units with low aspect ratios, do not benefit from reinforcing steel to control cracking. In general, reinforcement should only be added to the design when needed for shipping and handling, setting, increased safety or to address other non-structural stresses.

Due to the limitless shapes and sizes cast stone can take on, it is impractical to address every situation where reinforcement is beneficial. Generally, a minimum area of reinforcement equal to 0.25% of the unit cross-sectional area is recommended when units exceed fifteen (15) times the minimum thickness in any principal direction. Cantilevered, over hanging or other higher risk units should also be reinforced in the direction of greatest stress. Suspended units, including soffits, should be reinforced to engage the cast-in inserts and to hold together fractured pieces if damage were to occur.

One misconception about reinforcement in concrete is that it will prevent cracking, but reinforcing steel is only able to distribute cracks and minimize crack width. And no amount of reinforcement will prevent cracking in slender cast stone units (high aspect ratio). The Cast Stone Institute suggests that designers consult with the manufacturer to avoid incorporating units that will be prone to cracking based on their dimensions and geometry.

Most non-structural, low aspect ratio cast stone units may not benefit from embedded reinforcement. Therefore, the cast stone manufacturer should have the discretion to produce such units without reinforcement to avoid corrosion issues and increase the service life of the cast stone unit in the wall.

When required, reinforcing shall comply with the material requirements of ASTM C1364 – Standard for Architectural Cast Stone, TMS 504 - Standard for Fabrication of Architectural Cast Stone or D7957/D7957M Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement. It should be noted that welded wire fabric reinforcement should not be used in Vibrant Dry Tamp (VDT) products. All reinforcement should be shown on the shop drawings that are submitted by the manufacturer for approval.

Some cast stone producers use synthetic fiber reinforcement to control plastic drying shrinkage and thermally-induced cracking in wet cast produced cast stone. Concrete meeting the requirements of ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete may be used but it's not a substitute for conventional steel reinforcement.

The size of reinforcing bars is indicated 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" and 1/2" diameter respectively. Deformed bars are slightly larger than plain bars and provide improved bond strength with the concrete resulting in better tension resistance. Reinforcement type, size and placement within the cast stone should comply with the requirements of C1364 and TMS 504.



Tying reinforcing sections together prior to unit fabrication is usually not required with Vibrant Dry Tamp (VDT) units because the reinforcement is embedded into a layer of compacted fresh concrete during the manufacturing process. The use of three-dimensional reinforcing cage assemblies with stirrups is not recommended for Vibrant Dry Tamp units because voids can form around the reinforcement during the compaction process due to the non-fluid nature of the concrete. Eliminating these voids is important to developing bond strength between the bar and the concrete and reducing the potential for corrosion.

Cast stone units manufactured from wet cast concrete must have their reinforcement properly located and sufficiently rigid to prevent movement during the pouring process and to maintain the required concrete cover. Rebar chairs, which position the reinforcing steel away from the face of the mold are not recommended with cast stone. Special procedures must be followed to prevent reinforcing steel from telegraphing its location to the face of the units when this production method is used.

Reinforcing bar size should be kept to a minimum, even if this will require more bars to resist cracking and improve thermal stress distribution. Reinforcement should be placed symmetrically to prevent warping of longer units. The typical spacing of reinforcement is 12" on-center and should not exceed 18" on-center.

In summary, these guidelines should be considered, along with the discretion of the producer, to determine if reinforcement is needed for safe shipping and handling, setting, and non-structural stress. While an engineer is not required to review cast stone reinforcing steel placement, one may be consulted if a designer or producer has a unique application.

This Technical Bulletin addresses generally accepted practices, methods and general details for the use of Architectural Cast Stone. This document is designed *only as a guide* and is *not* intended for any specific application or project. It is the responsibility of design and construction professionals to determine the applicability and appropriate application of any detail to a specific project based on professional judgment, specific project conditions, manufacturer's recommendations and solid understanding of product characteristics. The Cast Stone Institute makes no express or implied warranty or guarantee of the techniques or construction methods identified herein. Technical references shall be made to the edition of the International Building Codes for the location of the structure, the latest edition of the TMS 402/406 Masonry Standards document and TMS 404, 504, 604 Standards for Design, Fabrication and Installation of Architectural Cast Stone.

The Cast Stone Institute (CSI) is a not-for-profit organization created to advance the design, manufacture and use of Architectural Cast Stone. To further this goal, the CSI continually disseminates information to targeted construction industry audiences through presentations, programs and technical publications.