ALLOWING FOR MOVEMENT OF MASONRY MATERIALS [1 of 3]

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.

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ALLOWING FOR MOVEMENT OF MASONRY MATERIALS [2 of 3]

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.