Building materials 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, moisture, loadings or other forces. Expansion joints allow for both expansion and contraction and may be vertical or horizontal.

THERMAL MOVEMENTS

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 may also be 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 stone wall 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. The manufacturer should be consulted for the shrinkage characteristics their cast stone exhibits.

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.

CAST STONE UNITS

Because shrinkage is expressed as a percentage, individual cast stone units will experience actual shrinkage depending upon their length. In the case of differential movements, hairline cracking is likely to occur when units are designed to lengths which are beyond the general rule of 15 times the thickness or a maximum length specified by an engineer.

Visible movement cracks exceeding 0.005 in. within the cast stone unit 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 cast stone units, units that do not carry any loads other than their own self weight and transfer wind loads, limiting the length of the cast stone can reduce the potential of cracking. As a general rule, 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 the Cast Stone. Increases in temperature can cause Cast Stone units to elongate, but decreases in temperature can have the opposite effect. The magnitude of these physical properties depends in part on the size of the unit. The combined effects of thermal and moisture movements in Cast Stone units and panels are often negligible, unless the units are 8 ft. or more in length in any direction. In this case, they may experience 1/8 in. or more in expansion or contraction due to combined thermal and moisture movements.

HORIZONTAL JOINT REINFORCEMENT

Depending on the project location, bond pattern, and other factors, it may be common practice to install horizontal joint reinforcing in the bed joints of a cast stone wall. On a project located in a high seismic region, where required by code, horizontal joint reinforcement may be used in conjunction with conventional bed ties. However, joint reinforcing may not be required where seismic loads are negligible. If the cast stone is set using mechanical anchorage, there is no evidence that horizontal joint reinforcing will add any strength, but may only aide in holding the mortar in place. Should unplanned cracks occur in the wall due to the lack of adequate movement joints in the system, horizontal joint reinforcing may help to keep the cracks in the mortar to a minimum.

Reference TMS 404-16 Standard for Design of Architectural Cast Stone Section 4.2 regarding vertically aligned bond with Commentary and Figures C4.2-1 and C4.2-2. These are found on pages D5 and D6.

RECOMMENDATIONS

In some cases, Cast Stone units laid in mortar may 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.

Hairline cracks may occur along the head and bed joints as both the mortar and the cast stone units experience shrinkage. But this can be minimized if the mortar is tooled when thumbprint hard. Furthermore, hairline cracks can be minimized by keeping lengths of Cast Stone units to within the limits dictated by principles of masonry construction. If the wall is properly designed, any hairline cracks that do occur will not affect the structural integrity of the wall. Large cracks can be avoided by incorporating control joints and other recommended details. Spacing of control joints depends on several factors such as project location, type of masonry, wall dimensions, etc. Therefore, the required spacing of control joints will vary greatly based on the project conditions. Cast Stone units that are to be wetted before installation must be wetted on those surfaces which are to be set in mortar in order to aide in achieving proper bond with the mortar and mitigate cracking in the mortar joints.

As required, total linear drying shrinkage shall be based on tests of cast stone units of any configuration or dimension made with the same materials, concrete mix design, manufacturing process, and curing method, conducted in accordance with Test Method C426 and within 24 months of production of the units.

Refrain from installing units until they have been cured to Cast Stone Institute specifications. Also, 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.

Consult a designer and/or engineer in order to determine where expansion joints should be placed to ensure the wall meets the design requirements.

