Brick: Any Way You Want It

By J. Gregg Borchelt, P.E.

Figure 2: Molded brick in wooden molds, being rotated to remove the molds.

The brick industry is alive, albeit not thriving right now. Brick production is down from its most recent high of 9.6 billion brick in 2008, but progress is still being made on the manufacturing front. More efficient processes to form and handle the brick and in the firing process continue to be made.

The majority of brick (90%) are formed by the extrusion process. The prepared raw materials are forced through a die that establishes the width and length of the brick. The die opening contains rods that introduce openings (cores) in the bed surface of the brick when laid as a stretcher (*Figure 1*). The extruded column is then cut to provide the height of the brick. The remaining 10% of brick production are molded *(Figure 2)*. The prepared raw materials are thrown or pushed into wood or steel boxes, with the excess cut from the top. That provides the shape. Yes, some molded brick are still made by hand.

Extruded brick often have coatings or textures, or both, applied to the extruded column before being cut to height. Molded brick have more rounded edges and often a sand coating that assists in release from the mold. The variations in raw materials, means of forming, adding coatings and firing conditions gives rise to thousands of appearances.

The transformation from a piece of mud to a brick is achieved by subjecting the brick to temperatures that cause a melting of the mineral particles, often upwards of 2,000 degrees F (1090 degrees C). This ceramic fusion, on cooling, changes the chemical and physical properties, providing the strength and durability for which brick is renowned. The firing takes place in either a long-tunnel kiln or round, "beehive" shaped kiln (*Figures 3* and *4*). Tunnel kilns process brick as they move through on rail-type flat cars. The firing temperature and time exposure are relatively easy to control. This results in brick with fewer dimensional and color variations. With a beehive kiln, the unfired brick are stacked inside and the entire mass is heated and cooled before unloading. The temperature and length of exposure varies with location in this periodic kiln. This results in brick with greater size and color variations. Fewer beehive or periodic kilns are in use due to its more labor-intensive nature.

Figure 1: End of extrusion machine, with clay column before texturing and cutting for brick height, left. Adjacent die with rods that form cores in bed surface visible, right.

Brick dimensions are typically given in the order of width by height by length. Many manufacturers are reducing the nominal width (thickness) of their brick, from 4 to 3 inches. More thin brick, less than 1¾ inch in width, are also being produced. These thin brick are often used as a facing on concrete panels and adhered to structural backings. Face dimensions, height and length, are increasing. Several manufacturers now produce brick with nominal face dimensions of 4 and 8 inches in height and 12 and 16 inches in length. Molded brick typically are not available in larger sizes.

Most kilns are fired with natural gas. Coal and sawdust also are used for firing brick. Several plants feature the use of waste products as fuel, or use fuel from renewable sources. These plants use either petroleum coke or methane captured from landfills as a supplement to natural gas to fire brick. Use of methane is not new, having been used since the 1980s.

Although automation of brick plants has been underway for decades, recent plants utilize robots to handle the brick from forming to packaging. The first human contact is often that of the bricklayer. Most kiln stacks are equipped with scrubbers to reduce air pollution. Many brick companies are taking advantage of the downturn in construction to improve the operating efficiency of their plants. Typical efforts include better utilization of heat; replacing electric motors with more efficient ones; and, obtaining water from non-municipal sources. With some green building rating systems, these practices can result in points for manufacturing with reduced resources.

One advantage of not operating production facilities at near capacity levels is the ability to work on new products. Brick with higher void areas, brick less than the 4-inch nominal bed depth, brick with larger face dimensions and new brick sizes come to the market. Of course, new coatings and colors are being investigated since brick is typically an exposed material.

Specifications for Brick

There are three specifications for brick used in building and above-grade structures. All are prepared by the ASTM International Subcommittee C 15.02 on Brick and Clay Tile. Although brick is used primarily as a veneer (where there is no structural demand), each of the following specifications can also be used for brick when brickwork is used as a structural member. *Figure 5* shows a detail of a brick veneer wall.

ASTM C 62 Standard Specification for Building Brick
ASTM C 216 Standard Specification for Facing Brick
ASTM C 652 Standard Specification for Hollow Brick

Let's examine some differences and similarities in these documents, and how the brick from them are used.

Figure 3: Extruded brick on kiln cars; tunnel kiln in background.

Figure 4: Beehive kiln.

Each of these specifications contains essentially the same requirements for durability. These are based on the included requirements for maximum water absorptions and minimum compressive strength. These properties verify that the ceramic materials are well fired and the brick has freeze-thaw resistance. Specify Grade SW requirement for brickwork exposed to weather for virtually all locations in the United States.

Don't be misled by the relatively low compressive strength requirement in the specifications (an average value of 3,000 psi). The average compressive strength of brick is about 10,000 psi. This results in tested masonry compressive strengths in the 4,000+ psi range, verifying a specified compressive strength of masonry ($f'm$) of the same value.

If structural brickwork is used, have the brick and mortar tested as a masonry prism to find out just how strong the combination is instead of using numbers in a table from the building code or a specification. One suggestion for better pricing with structural masonry is to specify Type S mortar rather than Type M. Type S provides better workability for the mason, with little affect on compressive strength. The building in *Figure 6* is structural brickwork.

Both C 62 and C 216 are for "solid" brick. That means that the brick are permitted to have a net cross-sectional area of 75 to 100%. For structural design purposes the building codes consider a "solid" brick to be 100% solid; the net area is 100% of the specified area. Hollow brick conforming with C 652, as the name implies, have net cross-sectional area less than 75% *(Figure 7, page 24)*. There are two classifications: H40V with net area from greater than 25 to 40% and H60V with net area from greater than 40 to 60%. The H40V brick are often used for veneer applications. The lower amount of material compared to solid brick makes the H40V brick a logical choice for green building. H60V brick have a

Figure 6: High rise load-bearing brick building, Park Lane Towers, Denver, CO. Courtesy of Diane Travis, Rocky Mountain Masonry Institute.

Figure 5: Brick and concrete masonry wall under construction.

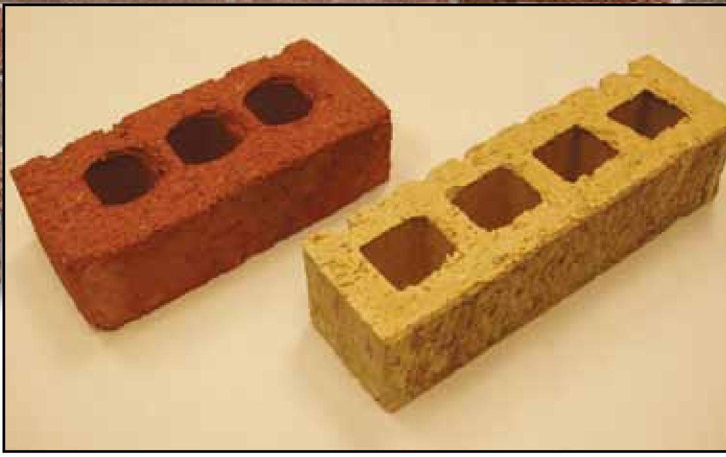

Figure 7: Solid (left) and hollow extruded brick.

Figure 8: Hollow brick with reinforcement for load-bearing wall. Courtesy of Joe Welte.

larger core, which serves as a location for reinforcement *(Figure 8)*. The higher compressive strength of brickwork results in a great structural system. Thus, they are typically used for structural masonry. Net area or minimum mortar area is used for structural design purposes.

Each of these standards has a requirement for the distance from the exposed face to any core in the brick. There is no requirement for the size or location of the cores. That permits the engineer and architect to work with the brick manufacturer to meet project specific requirements. The process of forming the brick can be modified to achieve a specially-shaped brick for bonding of brick around returns, for alignment of cores from course to course to receive reinforcement, or to achieve architectural effects such as projections and recesses.

C 62 includes only two appearance related requirements: dimensional tolerances and conformance to a selected sample. This is unusual, since brick is typically used as an exposed material. However, costs may be reduced if C 62 brick is used in situations where the appearance does not matter. Both C 216 and C 652 do include appearance requirements: limits on chips, warpage and out-of-square, and tighter tolerances on dimensions. Appearance requirements are identified with a classification by Type. A specified Type (FB in C 216 or HB in C 652) that includes the letter S indicates the typical production requirements; an X indicates tighter appearance requirements; and an A is for brick selected for a specific appearance with more variation in size. C 652 includes a Type HBB, which is similar to C 62 in that there are no appearance requirements.

Current ASTM Activities

All standards undergo periodic review and change. This is the case for the brick specifications under the jurisdiction ASTM Subcommittee C 15.02 on Brick and Clay Tile as well. The most significant change under consideration is a reduction in the net area under C 216. The lower limit is proposed to be changed from 75 to 70%. While this may appear to overlap with the limits in C 652, C 216 requires a thicker dimension from the outside face to a void area. This difference in thickness affects several architectural detailing considerations.

C 15.02 has been moving toward making the wording of the brick standards more consistent for several years. The objective is to combine several of the standards so that there are fewer to work with and understand. It is hoped that this will make it easier for engineers and architects to specify brick.

Improvements in test methods for brick and a better explanation of the content of the specifications are also on the subcommittee's agenda. Of course, the subcommittee welcomes members from the engineering community.

Sustainability and Brick

As with most construction materials, brick manufacturers and the Brick Industry Association are addressing the sustainable aspects of brick and brick buildings. Several topics related to this are mentioned in this article. Some additional points are:

- Raw materials are mined near the brick plant
- Over 95% of the mined material is in the finished product
- Most brick have recycled content, ranging up to 90%
- Brick plants are well distributed; 49 of the 50 largest Metropolitan Statistical Areas have at least two brick plants within 500 miles

Most engineers are familiar with the longevity of brick buildings. Many of the historical events of the United States occurred in brick buildings that are still in use. The legacy and feeling of cities and towns are represented by the brick buildings in them. Many engineers have assisted in adaptive reuse of older brick buildings. They help transform older mills, schools, manufacturing facilities and homes into hotels, residential units, offices, shopping centers and restaurants. They evaluate the structural capabilities of walls and columns that are over 100 years old. They improve connections to floor and roof systems to mobilize the inherent strength of these elements. They bring the performance of these buildings to that of the current building codes. I encourage the readers of STRUCTURE to send me information on the rehabilitation projects they have worked on.

Brick Industry Support

Most structural engineers should be familiar with the website of the Brick Industry Association, **www.gobrick.com**. It includes technical information on the use of brick. The *Technical Notes*, accessed through the tab of the same name, include a detailed discussion of many aspects of brick and its use. The individual *Technical Notes* cover a variety of subjects, including the sustainable aspects of brick, *Technical Note 48*. If you are not able to locate the information you need, send an email to **info@bia.org** or to me. One of the staff engineers will provide your answer.▪

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