THE BRICK INDUSTRY ASSOCIATION

TECHNICAL NOTES on Brick Construction

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Ceramic Glazed Brick Exterior Walls

Abstract: Buildings and other structures employ glazed brick in a variety of uses, from decorative bands to entire wall systems. Due to the imperviousness of its ceramic glazed surface, a vented air space is recommended behind the glazed brick wythe. Proper wall design, detailing and material selection, along with quality construction will result in attractive glazed brick applications exhibiting durability, structural stability and virtually maintenance free aesthetics.

Key Words: ceramic, condensation, drainage, expansion joints, flashing, glaze, moisture, movement, vents, weeps.

SUMMARY OF RECOMMENDATIONS

General:
- Consult manufacturers for assistance with special shapes and to determine the property requirements of double-fired glazed units
- Specify surfaces other than stretcher faces to be glazed

Wall System Design:
- Use vented drainage walls to ensure the most rapid removal of moisture that enters the wall
- Specify concave, "V", or grapevine mortar joint profiles

Air Space:
- 2 in. (51 mm) minimum air space recommended, required to be no less than 1 in. (25.4 mm)
- When prescriptive anchor spacings are used, air space may not exceed 4½ in. (114 mm)

Flashing:
- Extend flashing to the face of the brickwork or beyond
- Install at all horizontal interruptions to the air space
- Turn flashing ends into head joint a minimum of 1 in. (25.4 mm) to form end dam

Weeps:
- Open head joint weeps spaced no more than 24 in. (610 mm) o.c. recommended
- Most building codes permit weeps no less than 3/16 in. (4.8 mm) diameter and spaced no more than 33 in. (838 mm) o.c.
- Wick and tube weep spacing recommended at no more than 16 in. (406 mm) o.c.

Vents:
- Place vents at the tops of walls and below horizontal interruptions such as shelf angles and flashing locations
- Use open head joint weeps as vents; If weeps are not open head joints, vents are needed one or two courses above weeps
- Space vents 24 to 48 in. (610 mm to 1.22 m) o.c.
- Stagger vents in relation to overlying weeps

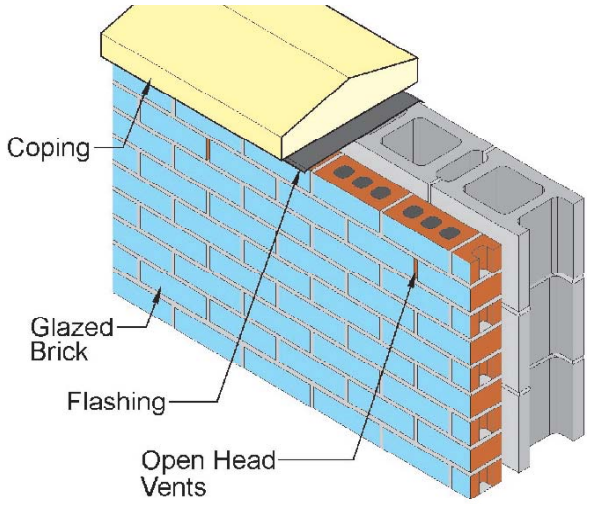
INTRODUCTION

Glazed brick can be used in both interior and exterior applications, as accent brick or as the field brick covering the entire facade, as shown in Photos 1 and 2. Glazed units have been integral parts of buildings for decades and have performed well under all climatic conditions. Glazed brick are often selected for use because of the many characteristics that make them distinct among brick products. One of these is the wide variety of colors that are not available in standard brick production. These may be applied to special shapes or brick of different sizes to further enhance visual interest. It is even possible to apply multiple glazes to a single brick unit, as shown in Photo 3. Glazes may be clear, translucent or opaque, and are available in almost any color with a glossy, satin or matte finish.

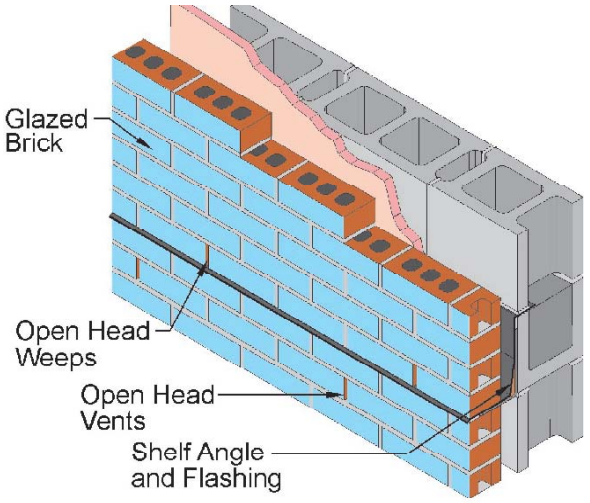
Glazed brick also provide an impervious surface that is extremely durable and resistant to staining which results in easy maintenance. Resistance to scratching and abrasion, as well as fire resistance of the glaze, also enhance the durability of glazed brick units.

Successful performance of exterior glazed brick walls can

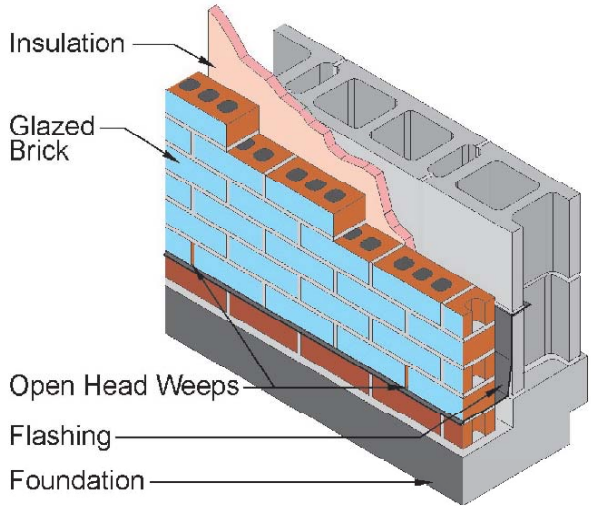
Photo 1
Glazed Brick Used for Entire Facade



a) Glazed Brick at Top of Wall



b) Glazed Brick at Shelf Angle



c) Glazed Brick at Foundation

Figure 1
Glazed Brick Wall Sections

be ensured through the use of vented drainage wall systems that allow water to evaporate from the unglazed back surface of the brick as well as through mortar joints. Other wall systems utilizing glazed brick exist and are serviceable, but are outside the scope of this *Technical Note*.

Attention must be given to proper material selection, detailing and construction practices to ensure successful performance. Proper design and installation of exterior glazed brick walls allows water drainage and minimizes the possibility of water being trapped behind the glazed surface which may lead to efflorescence or spalling. As in all brick construction, stress concentrations due to restrained movement must also be minimized. This *Technical Note* addresses these concerns and offers recommendations to ensure proper performance.

WALL SYSTEM DESIGN

Moisture Resistance

It is recommended that exterior glazed brick walls be designed to drain water that enters the wall system and to allow moisture from wind-driven rain or condensation to evaporate from the behind the brickwork. Therefore, a vented drainage wall system is recommended. Drainage walls must be designed, detailed and constructed properly to accommodate the flow of water collected within the wall. Common examples of drainage walls include brick and block cavity walls, brick veneer, and rain screen walls. See *Technical Note* 7 for more information on water penetration resistance.

In drainage wall design, penetrant water is intended to drain down the back of the brick, which is separated from interior wall elements by an air space. While a minimum 1 in. (25.4 mm) air space is required, 2 in. (51 mm) is recommended. Flashing and weeps are needed at horizontal interruptions in the air space to collect water and direct it out of the wall system, refer to Figures 1a, 1b and 1c. They are typically provided above lintels and shelf angles, beneath sills, under copings and masonry or stone caps, and at the wall base. Discontinuous flashing, such as at window sills and loose lintels, should be constructed with end dams to ensure that collected water is directed out of the brickwork. End dams are also recommended where stepped flashings are used, such as at sloped grades, above arches, and above sloped roofs. Weeps must be provided in head joints directly above the flashing. Open head joint weeps are recommended with a spacing of no more than 24 in. (610 mm) on center. Spacing of wick and tube weeps is recommended at no more than 16 in. (406 mm) on center. Most building codes require weeps to have a minimum diameter of $^{3}/_{16}$ in. and permit weeps to be spaced up to 33 inches (838 mm) on center.

Mortar joints affect the moisture resistance of brickwork since they can account for up to twenty percent of the brickwork surface. Selecting mortar joint profiles that are

most resistant to water penetration and cover the bed surface of the brick unit further minimize water intrusion and the possibility of water being trapped behind the glazed surface. Thus, concave, "V" and grapevine tooled mortar joints are recommended.

Vents. Vents placed at the top of glazed brick wall segments, as shown in Figures 1a and 1b, encourage air circulation and help to dissipate moisture within the air space. These vents should be located a course or two below horizontal interruptions of the air space such as shelf angles and flashing locations and be spaced 24 to 48 inches (610 mm to 1.22 m) on center. The vent should be an open head joint and may include a weep vent or louvered insert to deter insect access. In multi-story construction, the horizontal placement of vents and weeps should be staggered, or louvered inserts may be utilized to prevent draining water from entering vents. When wick or tube weeps are used at the base of a wall, additional vents should be added no more than two courses above weeps to best assure air movement through the air space.

Caps, Copings and Sills. Glazed brick should not be used in locations where they are likely to be saturated. Rowlock courses of brick used as caps, copings or sills are vulnerable to water penetration, especially when the slope is not sufficient to drain water away quickly. Therefore, glazed brick should be avoided in favor of concrete, stone, or metal elements that reduce the potential for water penetration at these locations. More information about caps and copings can be found in *Technical Note* 36A.

Movement

Brick masonry walls expand or contract with changes in temperature and moisture content. Brick expansion and other building movements are typically accommodated by expansion joints, placed vertically and horizontally, which divide the wall into rectangular segments and limit cumulative movement. Segment lengths and heights will vary with the building and wall design; however, expansion joints must be placed beneath all shelf angles.

Expansion joints are typically needed near corners, at changes in wall height, at offsets in the wall plane and at the ends of elements rigidly anchored to the backing or structure. The segments formed by expansion joints should be limited to a maximum length of approximately 25 feet (7.62 m). Segment lengths in building parapets should be limited to approximately 15 feet (4.57 m). The building geometry will also dictate locations for vertical expansion joints in glazed brick walls. Vertical expansion joints should extend full height from the foundation to the roof, or between locations of horizontal support.

Brick masonry expansion joints must be formed with highly compressible materials and be free of mortar and obstructions. Expansion joints are typically ⅜ in. (9.5 mm) or ½ in. (12.7 mm) wide with a foam backer rod and elastic sealant at the wall face to prevent air and water penetration from the exterior. See the *Technical Notes* 18 Series for more discussion regarding building movements and expansion joints.

Structural Design

Glazed brick can be used in loadbearing, cavity or veneer walls and should be designed in accordance with the appropriate chapter of ACI 530/ ASCE 5/ TMS 402, *Building Code Requirements for Masonry Structures*, also known as the Masonry Standards Joint Committee (MSJC) Code. [Ref. 11] Design can be based on either the requirements for veneer in Chapter 6, or the rational design approach of Chapters 2 or 3. In either case, the preferred design should be based on minimizing the potential for cracking of the glazed brick wythe under applied loading. More detailed information on structural design of veneer walls and cavity walls are included in the *Technical Notes* 28 Series and *Technical Notes* 21 Series, respectively.

Photo 2
Glazed Brick Used as Accents

The MSJC Code and Specification also contain material, size and spacing requirements for wall ties in cavity walls and anchors in veneer walls. Anchor and wall tie spacing in the MSJC Code depends on the wall design method and anchor type. See the *Technical Notes* 28 Series for anchor spacing in veneer walls and the *Technical Notes* 21 Series for spacing of wall ties in cavity walls.

Photo 3
Multiple Glazes, Shapes and Sizes Add Variety

MATERIALS

Glazed Brick

Two methods are used to apply glazes to brick bodies: a single-firing process and a double-firing process. In the single-firing process, the glaze is applied to the unfired brick body and is fused to the body when fired. In the double-firing process, brick that have been fired previously have a glaze applied and are fired again to fuse the glaze onto the brick. For some glazes with certain compositions or color pigments, double-firing is necessary to ensure the proper firing of the brick body at a higher temperature and the proper color and finish of the glaze at a lower temperature. Both methods result in quality glazed brick. ASTM standards for glazed brick include requirements for both brick body and the glazes.

Body Properties. The physical properties of brick vary depending on raw material, method of forming, and the degree of firing. ASTM standards establish indicators of durability based only upon physical property requirements that correlate with freeze thaw testing.

Single-fired glazed brick must meet the requirements of ASTM C 1405, Standard Specification for Glazed Brick (Single Fired, Brick Units). This standard establishes minimum criteria for the glaze as well as for solid and hollow brick bodies. Single-fired glazed brick intended for exterior exposure should meet the property requirements for Class Exterior. These include prescriptive requirements for minimum compressive strength, maximum cold water absorption and maximum saturation coefficient as shown in Table 1. The saturation coefficient requirement does not apply provided the average compressive strength of a random sample of five brick equals or exceeds 8000 psi (55.2 MPa) with no individual strength less than 7500 psi (51.8 MPa) and the 24 hr cold water absorption of each unit does not exceed 6.0%. The saturation coefficient and water absorption requirements do not apply if a sample of five brick pass the freezing and thawing test in ASTM C 67.

Currently, proper specification of double-fired brick units requires the designer to adopt two separate ASTM standards: ASTM C 126, Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units to cover applicable properties of the ceramic glaze finish, and ASTM C 216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale); ASTM C 652, Standard Specification for Hollow Brick (Hollow Masonry Units Made from Clay or Shale) or ASTM C 1088, Standard Specification for Thin Veneer Brick Units Made From Clay or Shale to cover requirements for the brick body.

TABLE 1
ASTM C 1405 Physical Requirements of Clay Bodies for Glazed Units

Designation	Minimum Compressive Strength, psi (MPa), Gross Area		Maximum Water Absorption by 24-hr Cold[1], %	Maximum Saturation Coefficient[1,2]	
	Average of 5 Brick	Individual	Individual	Average of 5 Brick	Individual
Class Exterior	6000 (41.4)	5000 (34.8)	7.0	0.78	0.80
Class Interior	3000 (20.7)	2500 (17.2)			

1. The saturation coefficient and/or cold water absorption requirement(s) may not apply when other criteria are met. See Body Properties text for more information.
2. The saturation coefficient is the ratio of absorption by 24 hr submersion in cold water to that after 5 hr submersion in boiling water.

Specifying glazed brick in this manner addresses material concerns necessary for exterior use.

Conformity to the requirements of the appropriate standard is an indication of the ability of the brick to withstand internal stresses caused by freezing of moisture within its body.

Glaze Properties. Ceramic glazes produce a durable, aesthetically pleasing surface feature on brick. ASTM standards C 126 and C 1405 set minimum property requirements for glaze finishes. Both standards cover finish requirements for glazes applied to the body before the brick unit is fired (single-firing). ASTM C 126 also covers double-fired glazed brick when the glaze is fused to the brick unit at temperatures over 1500 °F (816 °C).

The ASTM C 126 and C 1405 property requirements for glaze finishes are listed below. One or more of the properties listed may not be applicable to some special decorative and textured glazes. Manufacturers should be consulted for the property requirements of these.

- *Imperviousness* - A wet cloth and water must be able to remove permanent blue black ink that has been allowed to dwell on the finish for five minutes, with no stain remaining on or beneath the surface.
- *Hardness and Abrasion Resistance* - Glazes must be rated above five on the Mohs hardness scale and resist scratching from ordinary glass or steel in addition to being subjected to an abrasion test.
- *Resistance to Crazing* - Glazes may not craze, spall or crack when subjected to one cycle of autoclaving.
- *Fire Resistance* - The brick body and glaze are rated "noncombustible" and must withstand temperatures up to 1900 °F (878 °C) without melting, distorting or releasing toxic fumes. They must also measure "0" flame spread, fuel contribution and smoke density when tested in accordance ASTM E 84.
- *Resistance to Fading/Chemical Resistance* - Glaze colors must not change from the approved sample after a 3 hr submersion in prescribed acidic and basic solutions.
- *Opacity* - When specified, ink applied to the brick body must not be visible through the glaze.

Appearance. Aesthetic characteristics of glazed brick are specified by grade and type in ASTM C 126 and ASTM C 1405. The two grades, S and SS, limit dimensional variations, distortion and set squareness criteria of the exposed face. The requirements of Grade S are utilized in most glazed brick projects. Where a higher degree of precision is necessary the more precise Grade SS units should be specified.

The type of a glazed brick indicates the number of glazed faces on the brick. Type I units have one glazed face, and Type II units are glazed on two opposite faces. Unless specified otherwise, the stretcher face (or exposed face of shapes) is coated with the glaze finish. When glazed surfaces other than those identified by Type I or Type II are required, the additional surface(s) should be specified. Brick which will be exposed on their ends, or on their bed surfaces as in recessed courses or quoins, should also be explicitly specified. Consultation with the brick manufacturer is advised to determine if the proposed glazed brick can be made.

Mortar

Mortar should conform to ASTM C 270 Standard Specification for Mortar for Unit Masonry. Type N mortar is typically recommended for exterior walls above grade. Type S may provide better flexural bond strength to brick having initial rates of absorption (IRA) under 5 g/min•30 in.² (5 g/min•194 cm²). Use of admixtures and additives is not usually recommended unless their effect on the masonry, masonry units and items embedded in the brickwork is known, and they do not detrimentally affect plastic or hardened mortar. ASTM C 1384, Standard Specification for Admixtures for Masonry Mortars provides methods to evaluate the effect of admixtures on mortar properties. See *Technical Note* 8B for more information on mortar selection.

Anchors and Wall Ties

Acceptable connectors for anchored masonry veneer and cavity wall applications include adjustable ties, unit ties, and ladder-type or tab-type joint reinforcement. Connectors may be of stainless steel conforming to ASTM A 580, carbon steel protected from corrosion by hot-dipped galvanizing conforming to ASTM A 153 or epoxy coatings conforming to ASTM A 884, Class A, Type 1, minimum 7 mils (175 μm) for joint reinforcement and ASTM A 899, Class C - 20 mils (508 μm) for wire items. For more information on selection of anchors and ties see *Technical Note* 44B.

Flashing

Flashing materials should be sufficiently tough and flexible to resist puncture and cracking. In addition, flashing should not degrade when exposed to ultraviolet light or when placed in contact with metal, mortar or sealants. Flashing materials are generally formed from sheet metals, bituminous-coated membranes, rubber, or combinations thereof. The selection is largely determined by cost and suitability. Asphalt-impregnated felt is not acceptable as a flashing material. The cost of flashing materials varies widely. It is suggested, however, that only superior materials be selected, since replacement in the event of failure is difficult. See *Technical Note* 7A for a more detailed discussion of flashing materials.

SUMMARY

As with any brick masonry wall system, performance is the result of successful material selection, design detailing and construction practices. While the recommendations contained in this *Technical Note* are similar to those for non-glazed brick, it is important to consider the imperviousness of the glazed brick surface. Consequently, attention to each aspect of design and construction is essential to obtain the intended service life of the structure. Therefore, some glazed brick designs may entail more thorough detailing, as they may be less forgiving of detailing and construction deficiencies than non-glazed brick. Ceramic glazed brick can present a bright, bold, colorful statement with a durable brick surface.

> *The information and suggestions contained in this* Technical Note *are based on the available data and the combined experience of engineering staff and members of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this* Technical Note *are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.*

REFERENCES

1. *Annual Book of ASTM Standards*, ASTM International, West Conshohocken, PA, 2005:

   Volume 1.03 - A 580/A 580M, Standard Specification for Stainless Steel Wire

   A 899, Standard Specification for Steel Wire, Epoxy-Coated

   Volume 1.04 - A 884/A 884M, Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

   Volume 1.06 - A 153/A 153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

   Volume 4.05 - C 126, Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units

   C 216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)

   C 652, Standard Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)

   C 1088, Standard Specification for Thin Veneer Brick Units Made From Clay or Shale

   C 1384, Standard Specification for Admixtures for Masonry Mortars

   C 1405, Standard Specification for Glazed Brick (Single Fired, Brick Units)

2. *Building Code Requirements for Masonry Structures* (ACI 530-05/ASCE 5-05/TMS 402-05), The Masonry Society, Boulder, CO, 2005.

3. *Specification for Masonry Structures* (ACI 530.1-05/ASCE 6-05/TMS 602-05), The Masonry Society, Boulder, CO, 2005.