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WATER RESISTANCE OF BRICK MASONRY MATERIALS PART II OF III

Abstract: This *Technical Notes* covers considerations and recommendations regarding the availability and selection of materials to obtain a satisfactory degree of water resistance in the design and construction of brick masonry walls. It is not the purpose of this *Technical Notes* to cover all materials or all conditions, but to illustrate the principles involved. There are undoubtedly materials available which would accomplish the goal of providing satisfactory water resistance, but are not addressed in this issue. Lack of specific reference to a material would not preclude its use providing the product met the necessary requirements of the specifier in obtaining water-resistant brick masonry.

Key Words: brick, coatings, corrosion resistance, flashing, grout, lintels, mortar, sealants, shelf angles, ties, weepholes.

INTRODUCTION

Water resistance of brick masonry depends on four key factors: design, materials, construction and maintenance. This *Technical Notes* discusses materials. Design for water resistance is addressed in *Technical Notes* 7 Revised and construction techniques are discussed in *Technical Notes* 7B Revised. The discussion of various aspects of maintenance will be covered in a future issue.

MATERIALS

The use of quality materials in the construction of masonry walls is of prime importance in attaining a satisfactory degree of water resistance. When water passes through brick masonry walls, it invariably does so through separations or cracks between the brick units and the mortar. Under normal exposures, it is virtually impossible for significant amounts of water to pass directly through brick units. Highly absorbent brick may absorb some water, but certainly do not contribute to an outright flow of water through the wall. The key item is the extent of bond between the brick units and the mortar. Extent of bond is a measure of the area of contact at the interface between brick and mortar surfaces. Bond strength, on the other hand, is a measure of the adhesion between brick and mortar. High bond strength of brick and mortar combinations may not necessarily result in an extent of bond that would provide high resistance to water penetration. It follows that better extent of bond results in increased water resistance of brick masonry. Tests over the years have shown that the strongest and most complete bond is achieved when the suction of the brick unit, at the time of laying, is below 30 g/min/30 sq in. (30 g/min/194 cm^2). As a result, brick with suction more than this value may have to be wetted prior to laying.

The standards for the choice of quality construction materials are those of the American Society for Testing and Materials (ASTM). ASTM has, for many years, developed standard specifications for basically all building materials. These specifications are based on laboratory tests and field experience and, in the case of brick units, are the result of experience gained over a span exceeding 100 years. It must be remembered that the use of ASTM specifications will not guarantee that the desired results will be produced, even if the product meets the appropriate standard in every respect. They are consensus standards, and they set *minimum* quality levels for products. These standards are the best guides available for the determination of quality construction materials.

Brick Units

The choice of quality brick units is very important. The choice of a particular unit will normally be based on such things as color, texture, size and cost. But, there are other, more important, items that need to be taken into account by the designer. These are durability, and mortar/brick compatibility.

Because the masonry will be wet during part of its life, the question of durability is of primary concern. Problems of cracking, crazing, spalling and disintegration can occur if an improper choice of brick is made. The ASTM specifications for brick are written to provide guidance to the designer in choosing the quality of brick unit for specific exposure conditions. All of the requirements for compressive strength, absorption and saturation coefficients are specified to predict the durability level of the units. *None of the ASTM requirements are provided as a guide for determining the degree of water resistance of the masonry.* The degree of water resistance is important to the durability of the masonry insofar as the more water that enters the system, the greater the probability that the masonry will be in a saturated condition during any freeze/thaw cycles. There is a *Note* in the ASTM brick unit specifications regarding the initial rate of absorption

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(suction) of the brick units which is provided as a guide only, *not* a requirement.

Brick Standards. There are several kinds of brick units used in construction today and each has its own ASTM standard, with its own specific minimum requirements for *Grade* and, in some cases, *Type*. *Grades* cover the physical requirements in the standard while *Types* cover finish, size and warpage. The most commonly used brick standards are:

1. Facing Brick - ASTM C 216
2. Building Brick - ASTM C 62
3. Hollow Brick - ASTM C 652
4 Ceramic Glazed Brick - ASTM C 126

Mortar and Grout

The proper choice of mortar and grout to use in a particular design situation is very important. The primary concern is to choose a mortar and/or grout which will bond well with the particular masonry units chosen. *Technical Notes* 8 Series provides detailed information on mortars and grouts for masonry.

Mortar. The two standards for specifying mortars for unit masonry are ASTM C 270 and BIA M1-88. Four types of mortar (M, S, N and O) are covered in each of the standards. ASTM C 270 covers mortars made with portland cement-lime combinations and those made with masonry cements. BIA M1-88 addresses only mortars made with combinations of portland cement and lime.

The Basic Rule - *No single type of mortar is best for all purposes.* The basic rule for the selection of a mortar for a particular project is: *Never use a mortar that is stronger (in compression) than is required by the structural requirements of the project. Always select the weakest (in compression) mortar that is consistent with the performance requirements of the project.*

This general rule must, of course, be tempered with good judgment. For example, it would be uneconomical and unwise to continuously change mortar types for various pieces or parts of a structure. However, the general idea of the rule should be followed, using good judgment and economic sense.

Masonry Cements - Proprietary mortar mixes (masonry cements) are widely used because of their convenience and generally good workability. However, there are some drawbacks to such proprietary mixes. As proprietary materials, their formulae are seldom disclosed by their manufacturers.

Because of a lack of tight limitations on the type and amount of ingredients permitted in masonry cements, and the wide variation permitted in air content, the properties of brick masonry constructed with masonry cement mortars cannot be predicted with any degree of assurance. For this reason, masonry cements per se cannot be recommended. The use of any particular brand should be based on its performance record and laboratory tests of masonry assemblages.

Grout. The standard for specifying grout for all masonry work, whether it be unreinforced or reinforced, is ASTM C 476. Two types of grout, fine and coarse, are addressed in this standard. Coarse grout differs from fine grout only in that it contains an addition of #4 aggregate (pea gravel) to the basic mix. The grout space between the brick masonry wythes or the cells in reinforceable brick units should be more than 2 in. (50 mm) when pea gravel is used. Fine grout should be used for dimensions less than 2 in. (50 mm). A minimum cavity width of 1 in. (25 mm) is recommended for fine grout use. Code requirements may dictate the minimum size grout space.

Ties

Ties in a masonry wall system are provided to connect two or more wythes together. In the case of a cavity wall, the ties are the mechanism for transferring lateral loads between the wythes. Wall ties can take the form of wire ties, wire joint reinforcing, adjustable wire ties or masonry bonders. One key item is to make sure that the type of tie chosen will not decrease the water resistance of the wall system.

Wire Ties. Wire ties, either Z-ties or rectangular ties, shall comply with ASTM A 82. They should be corrosion-resistant, 3/16 in. (4.8 mm) diameter steel or metal wire of equivalent thickness. Applicable ASTM standards for corrosion-resistant coatings or materials are discussed in a following paragraph of this section.

Wire Reinforcing. Continuous wall ties (joint reinforcing) may be used in cavity or solid walls when the wythes are composed of clay masonry units. These continuous wall ties may be either truss or ladder-type, with at least one side wire in each wythe.

When the backup, or the inner wythe of a cavity wall, is built using concrete masonry units, joint reinforcing is needed in the concrete masonry to control cracking from drying shrinkage. This control of cracking helps reduce water penetration to the interior. Reinforcing should be either three-wire joint reinforcing, or two-wire reinforcing with tab ties. In either case, there should be one wire for each shell of the concrete masonry wythe. Because of the potential differential movement between brick and concrete block wythes, the use of ladder-type rather than truss-type joint reinforcing is recommended.

Adjustable Wire Ties. In some cases, adjustable wire ties are the only way to tie masonry when courses in separate wythes do not line up vertically, or to accommodate large anticipated vertical differential movement between wythes in high-rise buildings. They should, however, be used with caution. Tests have shown that the strength and stiffness of such ties are drastically reduced if they are positioned to their maximum adjustment. This reduction can be as great as a factor of 10. The ties providing lateral support for the outer wythe should be capable of resisting both tension and compression, but should be designed to permit movement parallel to the plane of the wall in both a vertical and a horizontal direction.

Masonry Bonders. Masonry bonders are not used as much today as they were in the past. One of their main problems is that they provide a direct path for water penetration from the outside of the wall to the interior along the head and bed joints. As a result, they are recommended only in cases where water penetration is a minor design consideration, or in some instances where all wythes of a wall are of brick masonry.

Corrugated Metal Ties. Corrugated metal ties should *not* be used in masonry construction with the possible exception of brick veneer on residential construction, up to three stories in height. This recommendation is made because of: (1) their shape, which allows water to flow more freely to the interior; (2) their susceptibility to corrosion; and (3) their poor structural capacity for transferring loads between the wythes.

Additional Considerations. Other considerations which are common to most of the ties mentioned above also must be considered.

Drips - The use of drips in ties should be evaluated carefully. Drips may help to keep water from traveling across wire ties to the interior, but they also reduce the compressive and tensile strength of the tie in transferring the lateral loads between the wythes. Since this load transfer is very important for the structural strength of the wall assembly, the spacing of the ties should be reduced when they are manufactured with drips.

Corrosion Resistance - Corrosion resistance is usually provided by copper or zinc coatings, or by using stainless steel. To ensure adequate resistance to corrosion, coatings or materials should conform to the following specifications:

ASTM A 153 -Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware, Class B-3

ASTM A 641 -Specification for Zinc-Coated (Galvanized) Carbon Steel Wire, Class 3

ASTM B 227-Specification for Hard-Drawn Copper-Clad Steel Wire, Grade 30 HS

ASTM A 167-Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip, Type 304

The use of wire ties conforming to the corrosion resistance specified in ASTM A 641 should be limited to walls where the entire tie is embedded in mortar or grout. Where a portion of a tie is not embedded, i.e., crosses an air space or cavity, only ties conforming to ASTM A 153, ASTM A 167 or ASTM B 227 should be used. While it is felt that these are conservative recommendations, they are based on current available data.

Shelf Angles and Lintels

Shelf Angles. Where building codes or other factors do not permit the brick to be self-supporting for its full height, the veneer should be supported at each floor, or at least every other floor, by shelf angles. The shelf angles should be made of structural steel and properly sized and anchored to carry the imposed loads. Additional discussion and details may be found in *Technical Notes* 21 Revised and *Technical Notes* 28B Revised.

Corrosion Resistance - For severe climates and exposures, consideration should be given to the use of galvanized or stainless steel shelf angles. Even where galvanized or stainless steel shelf angles are used, continuous flashing should be installed to cover the angle. To ensure adequate resistance to corrosion, coatings or materials should conform to the following specifications:

ASTM A 123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip

ASTM A 167 - Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip, Type 304

Lintels. The proper specification of material for steel lintels is important for both structural and serviceability requirements. The steel for lintels, as a minimum, should comply with ASTM A 36-Specification for Structural Steel. For harsh climates and exposures, consideration should be given to the use of galvanized or stainless steel lintels. If this is not done, then the steel lintels will require periodic maintenance to avoid corrosion. See corrosion resistance requirements under shelf angles, preceding this section. *Technical Notes* 31B Revised provides additional information on structural steel lintels.

Flashing

Flashing in a masonry wall is important for the proper drainage of water that may penetrate the wall system. Therefore, the choice of proper flashing material is of utmost importance. Flashing materials are generally formed from sheet metals, bituminous membranes, vinyls or combinations. The selection is largely determined by cost and suitability. It is suggested that only superior quality materials be selected, since replacement in the event of failure will be exceedingly expensive.

Copper. Copper is durable, is available in special, preformed shapes, and is an excellent moisture barrier. Although exposed copper may tend to stain adjacent masonry, it is not materially affected by the caustic alkalies present in masonry mortars. It can be safely embedded in fresh mortar and will not deteriorate in continuously saturated, hardened mortar, unless excessive chlorides are present. When using copper flashing, prohibit the use of chloride-based additives in the mortar. Typical copper flashing is made from 10 to 20-oz sheet copper.

Plastics. Plastics are probably the most widely used flashing materials. Plastic flashings are tough, resilient materials, which are highly resistant to corrosion. However, because the chemical compositions of plastics vary widely, it is impossible to lump all plastic flashings into one generalized group. Little information is available regarding the durability of some of these materials, so it will be necessary to rely on performance records of the material, the reputation of the manufacturer, and where possible, test data to ensure satisfactory performance. Some of the critical areas are: (1) degradation resistance to ultraviolet light; (2) compatibility with alkaline masonry mortars; and (3) compatibility with joint sealants. Typical thicknesses of plastic flashings are 20 mil to 40 mil (0.5 mm to 1 mm).

Galvanized Steel. Galvanized coatings are subject to corrosion in fresh mortar. Although the corrosive products apparently form a very compact film around zinc, the extent of corrosion cannot be accurately predicted. Bending also reduces their durability by cracking the coating. Some zinc-alloy flashings are available, but, like many alloys, these may have properties considerably different from those of the pure metal. The minimum thickness for this type of flashing should be about 0.015 in. (0.38 mm).

Stainless Steel. Stainless steel is an excellent flashing material. It provides a good water barrier, and has excellent chemical resistance. ASTM A 167, Type 304, should be specified. The minimum thickness should be at least 0.01 in. (0.25 mm).

Combination Flashings. Combination flashings, such as copper laminated to felt or kraft paper, were developed to utilize the better properties of each of the materials making up the flashing while at the same time lowering their cost. It is beyond the scope of this *Technical Notes* to describe the various types of combination flashings and their properties. The manufacturers' literature should be consulted for the various flashings available.

Asphalt-Impregnated Felt. Asphalt-impregnated felt is *not* recommended as a material to be used for flashing in masonry construction. It is easily damaged during installation, and in many cases, turns brittle and decays with time.

Aluminum. The caustic alkalies present in fresh, unhardened mortar will attack aluminum. Although dry, seasoned mortar will not affect aluminum, corrosion can again occur if the adjacent mortar becomes wet. Aluminum should *not* be used as a flashing material in brick masonry construction.

Sheet Leads. Lead, like aluminum, is susceptible to corrosion in fresh mortar. Furthermore, where lead is partially embedded in mortar, in the presence of moisture, it develops a differential electrical potential, acting as the positive element of an electric cell. The resulting electrolytic action gradually disintegrates the embedded lead. Lead should *not* be used as a flashing material in brick masonry construction.

Weepholes

As mentioned in *Technical Notes* 7 Revised, weepholes must be used wherever flashing is located. Otherwise, the collected water has no way to exit the wall system. Weepholes can be made in a variety of ways. Some of the most common ways are leaving head joints open, using removable oiled rods, using plastic or metal tubes, or using rope wicks. There are also plastic or metal vents which are installed in lieu of mortar in a head joint during construction. There is no single method which produces the best weephole for all situations. As long as weepholes are placed at the required locations in the proper size and spacing, the specific type of weephole chosen is not critical. See details in *Technical Notes* 7 Revised for location and spacing of weepholes.

Sealants

One of the most important items for preventing water penetration is the use of proper sealants and caulking around openings in masonry walls. Too frequently, caulking is considered a means of correcting or hiding poor workmanship rather than as an integral part of construction.

The subject of joint sealants is far beyond the scope of this *Technical Notes*, but a few comments are in order. For normal joints around windows and other openings, where little or no movement is expected, caulking should be done using a solvent-based acrylic sealant or a butyl caulk. For joints subject to large movements, such as expansion joints, an elastomeric joint sealant, conforming to the requirements of ASTM C 920, should be used. This includes silicones, urethanes and polysulfides. In no case should an oil-based caulking material be used. Regardless of the type of sealant chosen, proper priming and backer rods are a must.

Coatings

The use of some type of external coating on the face of a brick masonry wall, such as paint or clear coatings, is something which should not be done without a detailed evaluation of the possible consequences. First, it may not solve the basic water penetration problem, and second, it could lead to more serious problems. *Technical Notes* 6 Revised and *Technical Notes* 6A should be consulted before any type of coating is applied to a brick masonry wall.

SUMMARY

This, the second in a series of *Technical Notes* on water resistance of brick masonry, has provided information on properly selecting quality materials for masonry work. Obviously, this *Technical Notes* cannot cover all materials or all conditions. The materials are listed to illustrate the principles involved and may not include all materials which are available.

The information contained in this *Technical Notes* is based on the available data and the experience of the technical staff of the Brick Institute of America. This information should be recognized as recommendations which, if followed with good judgment, should result in masonry walls that are resistant to water penetration.

Final decisions on the use of information, details and materials as discussed in this *Technical Notes* are not within the purview of the Brick Institute of America, and must rest with the project designer, owner, or both.

REFERENCES

For more detailed information on materials and topics discussed in this *Technical Notes*, the following publications should be consulted:

1. *Technical Notes on Brick Construction* 6 Revised, "Painting Brick Masonry", May 1972.
2. *Technical Notes on Brick Construction* 6A, "Colorless Coatings for Brick Masonry", April 1995.
3. *Technical Notes on Brick Construction* 8 Revised, "Portland Cement-Lime Mortars for Brick Masonry," Sept. 1972.
4. *Technical Notes on Brick Construction* 8A, "Standard Specification for Portland Cement-Lime Mortar for Brick Masonry", Sept. 1988.
5. *Technical Notes on Brick Construction* 8B, "Mortar for Brick Masonry-Selection and Controls," July-Aug. 1976.
6. *Technical Notes on Brick Construction* 21 Revised, "Brick Masonry Cavity Walls", Jan-Feb. 1977.
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   (b) Section 2-Nonferrous Metal Products, Volume 02.03.
   (c) Section 4-Construction, Volumes 04.01 and 04.05.
   (d) Section 15-General Products, Chemical Specialties and End Use Products, Volume 15.08.