NCMA TEK

National Concrete Masonry Association
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DESIGN FOR DRY SINGLE-WYTHE CONCRETE MASONRY WALLS

TEK 19-2A
Water Penetration Resistance (2008)

Keywords: architectural, capillary suction, coatings, construction details, flashing, moisture, single-wythe, tooling mortar joints, wall drainage, water resistance, water repellents, weep holes

INTRODUCTION

Single-wythe concrete masonry construction has become a predominant method of construction with the increased use of integrally colored architectural concrete masonry units. Single-wythe walls are cost competitive with other systems because they provide structural form as well as an attractive architectural facade. However, single-wythe concrete masonry walls, as opposed to cavity and veneered walls, require special attention regarding moisture penetration issues.

The major objective in designing dry concrete masonry walls is to keep water from entering or penetrating the wall. In addition to precipitation, moisture can find its way into masonry walls from a number of different sources. Dry concrete masonry walls are obtained when the design and construction addresses the movement of water into, through, and out of the wall. This includes detailing and protecting roofs, windows, joints, and other features to ensure water does not penetrate the wall.

SOURCES OF WATER IN WALLS

The following moisture sources need to be considered in the design for dry concrete masonry walls.

Driving Rain

Moisture in liquid form can pass through concrete masonry units and mortar when driven by a significant force. However, these materials generally are too dense for water to pass through quickly. If water enters the wall, it often can be traced to the masonry unit-mortar interface due to improperly filled joints or lack of bond between the unit and the mortar. Cracks caused by building movements, or gaps between adjoining building segments (roofs, floors, windows, doors, etc.) and masonry walls are other common points of water entry.

Capillary Suction

Untreated masonry materials typically take on water through capillary forces. The amount of water depends on the capillary suction characteristics of the masonry and mortar. Integral water repellents greatly reduce the absorption characteristics of the units and mortar, but may not be able to prevent all moisture migration if there is a significant head pressure – 2 in. (51 mm) or more. Post-applied surface treatments reduce the capillary suction of masonry at the treated surface as well but have little effect on the interior of the units. This is discussed in more detail later.

Water Vapor

Water as vapor diffuses toward a lower vapor pressure. This means it will move from the higher toward the lower relative humidity regions assuming no pressure or temperature differential. Vapor in air of the same humidity and pressure, but of different temperatures, will move from the higher

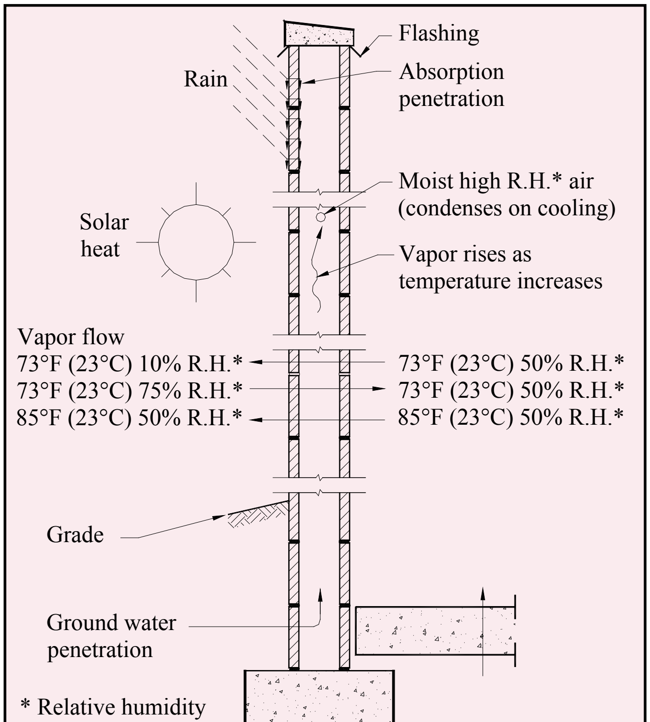


Figure 1— Moisture Sources

temperature to the lower. As air is cooled, it becomes more saturated and when it reaches a temperature called the dew point, the water vapor will condense into liquid form. See Figure 1.

DESIGN CONSIDERATIONS

Physical Characteristics of the Units

Open textured concrete masonry units possessing large voids (a function of density, compaction, and gradation) tend to be more permeable than closed textured units. The type of aggregate and water content used in the production of the masonry unit also affect capillary suction and vapor diffusion characteristics. Units that lend to mortar joint tooling such as standard units and scored block will form a more watertight wall than split-face units which are a little more difficult to tool. Fluted units are the most difficult to tool and therefore, the most susceptible to leakage. Horizontal effects such as corbels and ledges that hold water are also prone to be less water resistant. Units should be aged at least 21 days if possible before installation to reduce the chance of shrinkage cracks at the mortar-unit interface.

Integral Water Repellents

The use of integral water repellents in the manufacture of concrete masonry units can greatly reduce the absorption characteristics of the wall. When using integral water repellents in the units, the same manufacturer's water repellent for mortar must be incorporated in the field for compatibility and similar reduced water capillary suction characteristics.

Integral water repellents make masonry materials hydrophobic, thereby significantly decreasing their water absorption and wicking characteristics. While these admixtures can limit the amount of water that can pass through units and mortar, they have little impact on moisture entering through relatively large cracks and voids in the wall. Therefore, even with the incorporation of integral water repellents, proper detailing of control joints and quality workmanship to preclude beeholes and unfilled or inadequate mortar joints is still essential. Another advantage of integral water repellents is that they not only help to keep water out but also inhibit the migration of water to the interior face of the wall by capillary suction. See TEK 19-1 (ref. 1) for more complete information on integral water repellents for concrete masonry walls.

Surface Treatments

For colored architectural masonry it is recommended that a clear surface treatment be post-applied whether or not integral water repellent admixtures are used. Most post-applied coatings and surface treatments are compatible with integral water repellents although this should be verified with the product manufacturers before applying. When using standard units for single-wythe walls, an application of portland cement plaster (stucco), paint, or opaque elastomeric coatings works well. Coatings containing elastomerics have the advantage of being able to bridge small gaps and cracks. More detailed information on surface treatments and water repellents is available in TEK 19-1 (ref. 1).

Wall Drainage

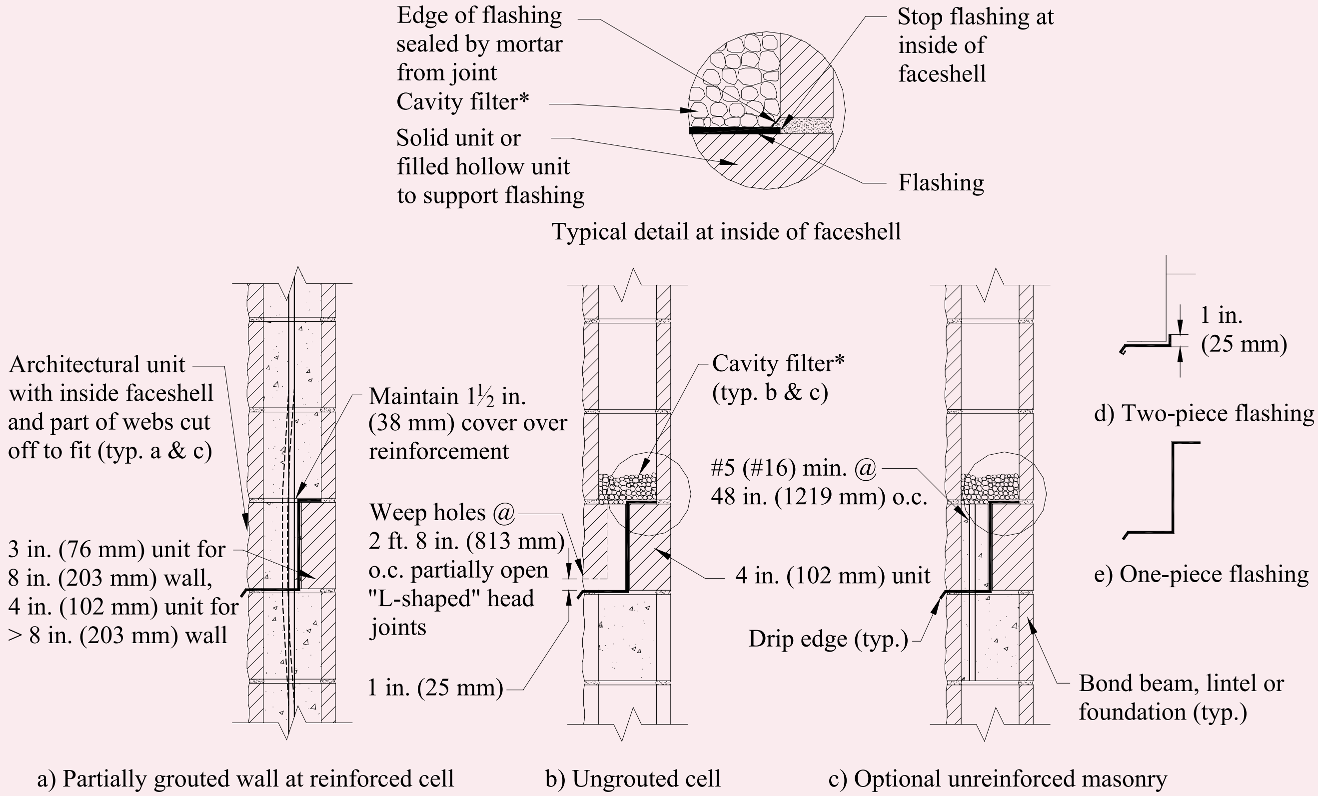
Proper detailing of masonry wall systems, to ensure good performance, can not be over emphasized. Traditionally, through-wall flashing has been used to direct water away from the inside face of the wall and toward weep holes for drainage. Modern techniques usually do not extend the flashing through the inside face shell of the wall, as shown in Figure 2, in order to retain some shear and flexural resistance capabilities. In reinforced walls, some shear is provided through doweling action of the reinforcement, and by design, the reinforcement takes all the tension per the *International Building Code* and *Building Code Requirements for Masonry Structures* (refs. 2, 3). Proper grouting effectively seals the vertical reinforcement penetrations of the flashing. The absence of reinforcement to provide doweling in plain masonry may be more of a concern, but loads tend to be relatively low in these applications. If structural adequacy is in doubt, a short reinforcing bar through the flashing with cells grouted directly above and below the flashing can be provided as shown in Figure 2c.

Critical to flashing performance is ensuring that a buildup of mortar droppings does not clog the cells or weep holes. A cavity filter, consisting of washed pea stone or filter paper, immediately above the flashing can be provided to facilitate drainage as shown in Figure 2. This should be accompanied by a means of intercepting or dispersing mortar droppings, as an accumulation can be sufficient to completely fill and block a cell at the bottom. Mortar interception or isolation devices that provide pathways for the water to migrate through the layer of mortar droppings or filling the cells with loose fill insulation, a few courses at a time as the wall is laid up, can disperse the droppings enough to prevent clogging. An alternative is to leave out facing block at regular intervals just above the flashing until the wall is built to serve as cleanouts. The units left out can be mortared in later. See TEKs 19-4A and 19-5A (refs. 4, 5) for an in-depth discussion and additional details regarding flashing.

In addition to conventional flashing systems, proprietary flashing systems are available that direct the water away from the inside face of the wall to weep holes without compromising the bond at mortar joints in the face shells. Specialty units that facilitate drainage are also available from some manufacturers. Solid grouted single-wythe walls are not as susceptible to moisture penetration, since voids and cavities where moisture can collect are absent, so do not need flashing. However, fully cured units and adequate crack control measures are especially important to minimize cracks. In some regions of the country, the bottom of the wall is recessed about an inch (25 mm) below the floor level to ensure drainage to the exterior. Veneer and cavity walls (sometimes referred to as drainage walls) of course provide the most moisture resistance.

Control Joints and Horizontal Reinforcement

To alleviate cracking due to thermal and shrinkage movements of the building, control joints and/or horizontal reinforcement should be located and detailed on the plans. Wall cracking provides an entry point for rainwater and moist air that may condense on the inside of the wall. Specification of a quality sealant for the control joints and proper installation is a must. TEK 10-1A and TEK 10-2B (refs. 6, 7) provide additional information on crack control strategies.



* Cavity filter is any material used to prevent mortar droppings from clogging the weeps, i.e. filter paper or 2 in. (51 mm) of washed pea stone or proprietary devices. Alt.−leave out every other reduced size facing unit on top of flashing to serve as cleanouts until the wall is completed.

Figure 2—Flashing Details to Maintain Structural Continuity

Mortar and Mortar Joints

The type of mortar and mortar joint also have a great impact on the watertightness of a wall. A good rule of thumb is to select the lowest strength mortar required for structural and durability considerations. Lower strength mortars exhibit better workability and can yield a better weather resistant seal at the mortar/unit interface. Concave or V-shaped tooling of joints, when the mortar is thumbprint hard, improves rain resistance by directing water away from the surface of the wall and by compacting the mortar against the masonry unit to seal the joint. This is especially important when using integral water repellent admixtures to avoid reduced bond strength and cracking at the head joints due to the decreased affinity of the units for water. Raked, flush, struck, beaded, or extruded joints are not recommended as they do not compact the mortar and/or create ledges that intercept water running down the face of the wall. Head and bed joints need to be the full thickness of the face shells for optimum watertightness. Head joints particularly are vulnerable to inadequate thickness (see Figure 4).

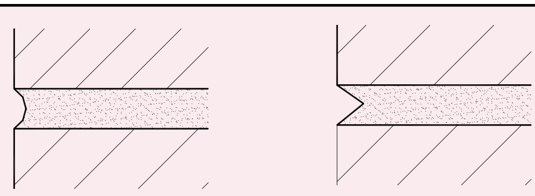


Figure 3—Weather Resistant Types of Mortar Joints

Vapor Retarders

Continuous vapor retarders to reduce the passage of water vapor into the wall generally are used only when insulation

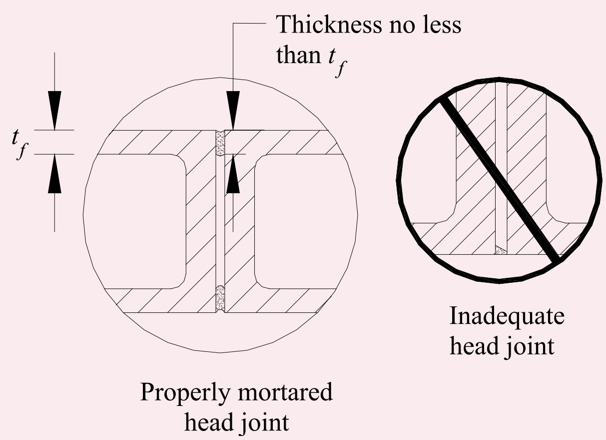


Figure 4—Head and Bed Joints the Full Thickness of the Face Shells are Crucial for Dry Walls

is placed on the inside face of the wall. The relatively small amount of moisture that does get through passes through the wall by diffusion, provided that a "breathable" surface treatment is placed on the exterior. Wall thickness and dew points are also determining factors regarding vapor retarder performance. Materials most commonly used for vapor retarders are plastic film, asphalt-treated paper and aluminum foil.

Cleaning

Concrete masonry cleaning methods can generally be divided into four categories: hand cleaning, water cleaning, abrasive cleaning and chemical cleaning. In general, the least aggressive method that will adequately clean the wall should be used, as overzealous cleaning can damage the water repellent characteristics of the wall. For example, walls with integral water repellents should not be cleaned with high-pressure water because it drives water into the masonry. If an integral water repellent has been used, the integral water repellent manufacturer should be contacted for detailed cleaning recommendations. Keeping the masonry wall clean as the construction progresses, using a brush and water, minimizes cleaning efforts after the mortar has hardened. See TEK 8-4A, *Cleaning Concrete Masonry,* (ref. 9) for more detailed information.

SPECIFICATIONS

Well-worded specifications are essential to ensure proper construction of the design details. Items to address in the contract documents in addition to those previously mentioned are:

1) All work should be in accordance with the *International Building Code* and *Specification for Masonry Structures* (refs. 2, 8).
2) Require a qualified mason by documentation of experience with similar type projects.
3) Require mock-up panels to assure an understanding of the level of workmanship expected and to be referred to as a standard of reference until the project is completed.
4) Proper storage of all masonry materials (including sand) at the job site to protect from contaminants such as dirt, rain and snow.
5) The tops of unfinished walls shall be covered at the end of each work day. The cover should extend 2 ft (610 mm) down both sides of the masonry and should be held securely in place.

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