Proper Design + Quality Materials + Good Workmanship = Well-Built Weathertight Masonry Walls

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INTRODUCTION

Weathertight walls, as used here, refers primarily to water resistant construction. Except for structural errors, 90 percent of all building construction problems are associated with water in some way. The water may be in any one of its three forms, liquid, vapor, or solid, and generally involves in some manner the movement and possible accumulation of water.

Building weathertight walls with any material requires three essential things:

- Proper design,
- Quality materials, and
- Good workmanship.

All three of these ingredients must be present to accomplish weathertight construction. Good design and quality materials together with poor workmanship will result in a leaky building. Good materials and superior workmanship cannot overcome faulty design, and the best design and workmanship cannot compensate for quality building materials.

Rain is the primary source of water that penetrates masonry construction. During periods of wind-driven rain, the air pressure at the outside of a wall is higher than the inside. This pressure difference forces water through any path available in the wall. Paths available may be one or more of the following:

- Through permeable masonry units
- Through the mortar joints, and
- Through the cracks or other openings in the wall.

If the wind forces are reduced to zero, the rain falls freely, striking wall coping, caps, and the roof. In this instance, water can reach the masonry wall either by absorption into the coping, or by drainage from the roof, or coping running down the wall face. Without wind, penetration into the masonry depends more on capillarity and generally will occur more slowly.

DESIGN

Solution to the problem of building weathertight masonry walls must start with the designer. Past approaches to solution of the problem have relied too much on better masonry materials and too little on design. Fortunately, recognition is growing that weathertight concrete masonry construction begins with the architect and his understanding of the factors affecting the performance of walls in relation to water penetration. Assuming quality materials placed with good workmanship, the designer must search each area of his design prior to construction to see if water can enter and where it will flow or accumulate once it has entered.

Wall Types — Three common types of wall constructions are the single-wythe, the multi-wythe, and the cavity. Of the three types, the cavity wall is the most resistant to water penetration, the multi-wythe solid wall next most resistant, and the single-wythe construction least. Unfortunately, cost for construction of the three types falls in the same order. The single-wythe concrete masonry wall is most economical and is employed extensively in all parts of the country. But the difference in the resistance to rain penetration for the three wall types needs to be recognized by the designer. In most geographic areas, exterior single-wythe walls require protective waterproof paint coatings, especially if the masonry units are open textured and fairly permeable. The multi-wythe and cavity constructions, on the other hand, can be used in "customized" architectural concrete applications without painting in all geographic areas. A clear coating to protect the architectural concrete surface against soiling by airborne contaminants is all that is required.

Joint Types — The various types of mortar joints used in concrete masonry construction, concave and vee types are considered best for use where the masonry will be subject to rain or freeze-thaw exposure. Beaded and weathered types have also performed satisfactorily. The other four types (flush, raked, extruded, and struck) should be used only where weathertightness is of no concern, such as indoors or protected.

MATERIALS

The individual materials of masonry construction have been more fully researched with respect to weathertightness than the other two factors: (1) Design, and (2) Workmanship. Past research is valuable in that it shows the range of performance characteristics one can expect from a specific material in a given exposure. Example: The ASTM Specifications for Concrete Masonry Units list different requirements for units exposed to different design conditions. There are units with different strengths, units with different unit weights, load-bearing and non-loadbearing units, etc. The same is true of the ASTM Specification for Mortars for Masonry.

Concrete Masonry Units — The precise concrete masonry unit selected for an exterior wall exposure will depend upon: (1) geographic area or anticipated weather conditions, and (2) the surface expression the architect desires in the finished structure. If the exterior walls are to be painted with a protective waterproof coating, the concrete masonry units should conform with:

- ASTM Designation C 90 for hollow, load-bearing units
- ASTM Designation C 129 for non-loadbearing units
- ASTM Designation C 145 for solid units
- ASTM Designation C 55 for concrete brick

If the exterior surface is to remain unpainted, that is, architectural face or customized concrete masonry, somewhat more stringent requirements are

necessary to assure durability and weathertightness. Most manufacturers of these premium units have developed their own recommended specifications which are usually more restrictive than ASTM Specifications. In the absence of a manufacturer's recommended specification, the strength and absorption requirements of ASTM C 55, Grade N, Normal Weight Concrete Brick may be employed for architectural facing units or customized units in exterior walls that are weathertight. ASTM C 55, Grade N, will provide a minimum compressive strength of 3500 psi and in the Normal Weight a maximum absorption of 10 pounds per cubic foot of concrete.

Mortar — The mortar properties required for weathertight concrete masonry construction are: (1) Workability, (2) Water retentivity, (3) Strength, (4) Adhesion, and (5) Durability. These properties may be obtained in mortars that comply with:

- ASTM C 270 for Mortar for Nonreinforced Masonry
- ASTM C 476 for Mortar for Reinforced Masonry

As with concrete masonry units, precise selection of mortar type will depend upon geographic area and the desired exterior surface treatment. If the wall surface is to be painted with an opaque protective waterproof coating, the mortar for nonreinforced masonry construction should comply with either grade N, S, or M of ASTM C 270, the exact choice depending upon structural loading rather than exposure. If the nonreinforced masonry is to be left unpainted or coated with a clear water repellant that is customized concrete masonry, then only type S or type M of ASTM C 270 should be employed. For reinforced masonry construction either type PM or type PL is satisfactory for both painted and unpainted situations.

Opaque Paint Coatings — Numerous waterproof coatings are available for the construction of weathertight concrete masonry walls. Generally these systems are two separate coats consisting of: (1) a fill coat to level out and fill the surface pores of the masonry, followed by (2) a finish decorative waterproofing coat. Repainting is, in most all cases, the finish coat only. The most common opaque paints are: (1) a latex base, (2) a portland cement base, or (3) a combination latex-portland cement base. Latex emulsions are: (1) polyvinyl acetates, (2) acrylics, and (3) styrene-butadienes. Properly applied, they can be relied on to give a satisfactory weathertight concrete masonry wall for up to 8 or 10 years in most geographic areas.

Clear Coatings — Concrete masonry used as an architectural facing (Customized Concrete Masonry) is usually coated with a clear water repellant so as to retain its original unpainted appearance. As a class, the clear materials tend to be less effective than opaque coatings because they must have a lower content of solids (30-35 percent or less) to avoid forming a glossy film on the masonry surface. They are accordingly called "Water Repellants" instead of "Waterproof Coatings." To be successful, the clear water repellants must be used with masonry having a dense surface free of large pores or voids, that is, masonry that does not require a fill coat.

A good clear water repellant coating should:

- Have good storage life and application characteristics.
- Not change the appearance of the masonry.
- Produce a surface that is resistant to rain penetration.
- Be of a breathing type so that water vapor can travel through it to prevent condensation within the wall.
- Resist efflorescence.
- Be durable and resist the accumulation of air-borne contamination on the wall.

WORKMANSHIP

Workmanship applies not only to the care and technique with which concrete masonry is laid, but also to certain elements in the design which depend upon good workmanship for proper execution. Workmanship can and does greatly influence the weathertightness of a concrete masonry wall. In fact, studies have consistently shown that workmanship is the single most important factor affecting rain resistance. Close cooperation between the mason and designer is necessary if the weathertight details drawn in the architect's office are to become a reality in the field.

Bonding — Bed joints should be full face shell in width and should not be laid too far in advance of laying the concrete masonry unit. If the mortar is spread too far ahead of actual laying of the block it will begin to dry out, stiffen, and reduce bond with the block. When leaks occur through the bed joint, it usually is due to incomplete bond between the mortar bed and the bottom of the block. Incomplete bond is caused in most cases by partial drying of the mortar prior to bedding of the unit due to spreading of the mortar too far in advance. To assist a more complete bond, the trowel should be moved upward from the bottom of the bed joint when striking off the excess mortar.

Head joints should be buttered one unit at a time and that unit then put in place immediately. The unit should be positioned by shoving it firmly in place with enough force to cause an extruded head joint. Then in striking off the extruded mortar, the trowel should be moved in the direction of the unit previously laid, again to assist in the formation of a more intimate bond between mortar and unit.

The masonry unit should never be moved or relocated after it has been laid and the excess mortar struck off. Any slight movement will break the bond between the block and the mortar and lead to a leaky wall.

The time at which the mortar joints are tooled is important to wall weathertightness. The commonly accepted and quoted procedure is to wait until the mortar is "thumb print hard" and then tool the joints. From a practical viewpoint this is not always feasible. The mason laying overhand from the floor of a loadbearing multi-story concrete masonry structure has access to the joints in the outer wythe for a limited period of time. Consequently, the mortar joints must be tooled as soon as sufficient water has left the mortar to allow tooling without bringing excessive paste to the surface.

Finally with regard to bonding, the mason should make certain all joints are filled with mortar, even those joints in composite or cavity wall construction that are hidden from view in the finished wall. Unfortunately, there have been a few cases where hidden head joints in high rise cavity wall construction were left unfilled and the omission discovered later when the building displayed bad leakage. The need to completely fill all hidden mortar joints is especially true in the case of the vertical collar joint in a structural composite wall. Here the filled collar joint not only serves as a barrier to water penetration, but also transfers horizontal shear across the joint from one wythe to the other thereby greatly increasing the wall's resistance to wind forces.

Flashing — Flashing should be installed exactly as shown on the plans, without being cut or punctured. When plans call for flashing and joint reinforcement or ties at the same elevation, the designer should be consulted. Chances are the steel can be relocated one course above or below the flashing so as to avoid puncturing it and spoiling it as a water barrier.

Mortar droppings should not be allowed to accumulate: (1) on flashings, (2) in weep holes, or (3) in the cavity space of a cavity wall. Droppings not only plug weep holes, but also provide a bridge for water to travel across a cavity thereby encouraging a leaky wall.

Wall Coatings — Good workmanship in the application of wall coatings is of paramount importance to weathertightness of concrete masonry construction. This is especially true with the clear water repellants where effectiveness depends upon solid content. Dilution of clear coatings prior to application is difficult or impossible to detect until it rains: then it becomes obvious.