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 proper 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 poor 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 mortar joints, and
- Through the cracks or other openings in the wall.

If the wind forces are reduced to zero, the rain falls slowly, 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-swepe, the multi-swepe, and the cavity. Of the three types, the cavity wall is most resistant to water penetration, the multi-swepe solid wall next most resistant, and the single-swepe construction least. Consequently, cost for construction of the three types falls in the same order. The single-swepe concrete masonry wall is most economical and is employed extensively in all parts of the country. But the difference in the resiliency to rain penetration for the three wall types needs to be recognized by the designer. In most geographic areas, exterior single-swepe walls require protective waterproof paint coatings, especially if the masonry units are open textured and porous permeable. The multi-swepe 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 scaling 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 weather-tightness is of no concern, such as outdoors or protected.

MATERIALS

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

The same is true of the ASTM Specifications for Mortar for Masonry.

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

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

If the exterior finish is to remain uncoated, that is, architectural face or custom-molded concrete masonry, some what more stringent requirements are
necessary to avoid 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 73. Grade N or Normal Weight Concrete Brick may be employed for architectural facing units or custom-made units in exterior walls that will be weathertight. ASTM C 55. Grade N, or Normal Weight Concrete Brick may be employed for architectural facing units or custom-made units in exterior walls that will be weathertight. ASTM C 55. Grade N, will provide a minimum compressive strength of 3,000 psi and in the National Institute 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 retention, (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 waterproofing coating, the mortar for nonreinforced masonry construction should comply with either Grade N, or M or ASTM C 270, the water choice depending upon structural loads. The masonry for reinforced masonry is to be left untreated or coated with a clear water repellent that is customized concrete masonry, then any type S or type M of ASTM C 270 should be employed. For reinforced masonry construction either type S or type M of ASTM C 270 is a time-saving treatment for both painted and unpainted surfaces.

Quick Paint Coatings — Numerous waterproofing 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 waterbase cement base, or (3) a combination latex-waterbase cement base. Latices emulsions are: (1) polysiloxane acetal, (2) acrylic, (3) rubbers. For proper application, they can be relied upon to give a satisfactory weathertight concrete masonry wall for up to 10 years in most corrosive areas.

Concrete Masonry — Concrete masonry units are usually coated with a clear water repellent so as to retain their 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 finish on the masonry surface. They are accordingly called "Water Repellants" instead of "Waterproof Coatings." To be successful, the clear water repellents 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 repellent 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 brushing 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.

WORMANSHIP Workmanship applies 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 do great injury to the masonry 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 architects and the contractor is necessary if the weather-tight details drawn in the architectural office are to become a reality in the field.

Bonding — Bond joints should be full face sheet in clay and should not be built too far in advance of laying the concrete masonry unit. If the mortar is spread too far ahead of actual layout of the block it will begin to dry out, stiffen, and reduce bond with the block. When leaks occur through the bond 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 avoid a more complete bond, the bond should be moved upward from the bottom of the bond joint where it is laid out to the exact location where it is to be laid.

Bed joints should be hadded over one time at a time and then cut in place with mini-cut three to cause an extended bed joint. Then in setting off the extended mortar, the mortar should be moved in the direction of the unit which presents a load, again to assist in the formation of a more intimate bond between mortar and unit.

The mortar 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 leaks wall. The time at which the mortar joints are tooled is very important to weather-tightness. The commonly accepted and queried procedure is to wait until the mortar is "thumb print hard" and then to too it out. 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 blowing excessive paste to the surface.

Finally with regard to bonding the mortar 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 disclosed 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 in addition it prevents any water from reaching the joint from one wythe to the other thereby greatly increasing the wall's resistance to wind forces.

Flashings — Flashings should be included as shown on the plans without having one provision or another. When plans call for flashings and joint remedial measures, the designer should be consulted. Choices are the steel (can be relocated one course above or below the flashing so as to avoid puncturing it and spall ing it) or mortar.

Mortar dropoffs should not be allowed to accumulate (1) on flashings, (2) in space joints, or (3) in the cavity space of a cavity wall. Dropoffs not only ruin neatness, but also provide a bridge for water to travel across a cavity thereby encouraging a leaks wall. A dropoff should be considered in the application to wall coating is of paramount importance to weathertightness of concrete masonry construction. This is especially true with the clear water repellant which is most effective when used under conditions of complete coverage. In the event dropoffs upon solid contact (blunt soft to clear coatings prior to application is a must) or even when applied over the concrete masonry wall, then it becomes obvious.