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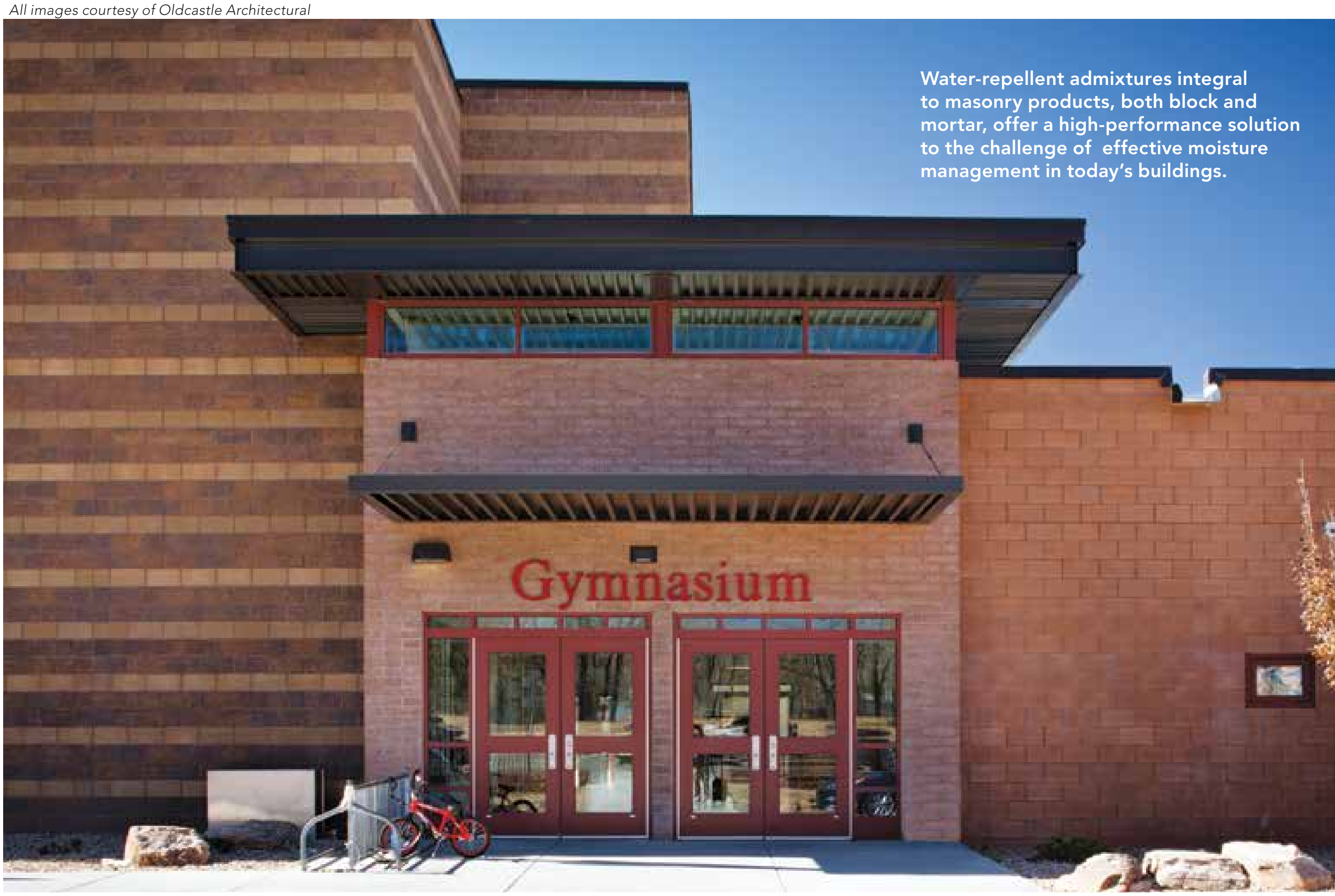

Water-repellent admixtures integral to masonry products, both block and mortar, offer a high-performance solution to the challenge of effective moisture management in today's buildings.

Controlling Moisture in Masonry

Resolving the number one cause of structural deterioration in buildings

Sponsored by Oldcastle Architectural

In 600 B.C. Lao Tzu, credited with authoring the esteemed spiritual classic known as the Tao Te Ching, weighed in on water. "Nothing in the world is more flexible and yielding than water. Yet when it attacks the firm and strong, none can withstand it, because they have no way to change it." Lao Tzu's words certainly ring true for the design and construction industries whose practitioners well appreciate the destructive potential of water which, in the wrong place at the wrong time, can cause devastating structural damage as well as mold and efflorescence. Properly protecting structures from moisture intrusion has been an ongoing mission in the design and construction environment, and advances in technology have enabled designers to specify the building materials and systems that limit intrusion through the wall facade. This article addresses not only the key concerns relating to moisture in masonry construction, but how to solve them through advancements in water repellent mortar and block systems that provide additional moisture control, environmental, and visual requirements.

MASONRY AND MOISTURE—WHAT CAN HAPPEN?

The design of masonry systems should prevent the intrusion of the elements, rain, snow, heat, and cold, into the building's interior, and it should safeguard the building's

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Learning Objectives
After reading this article, you should be able to:

1. Discuss flashing and other proper masonry installation strategies to manage moisture in a masonry wall.
2. Describe water-repellent admixture advances and uses in concrete block and mortar that help control moisture and meet green building codes.
3. Explain the advantages of complete masonry systems that mitigate water penetration and provide backup moisture management.
4. Specify a masonry solution that delivers superior moisture control and an environmentally sound structure.

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structural components. The design must be properly detailed, however, as there are many ways water can enter a masonry building—through porous or poor quality masonry units—mortar joints, hairline or shrinkage cracks, parapet, door and window details—in short, through any structural break in the wall. Water can also enter through vapor condensation and can penetrate the structure as a result of poor workmanship, with lack of proper drainage aggravating the impact of any type of moisture intrusion. Vapor condensation can also result from interior sources when thermal properties are not in alignment. The results can take a serious toll on a building along several fronts.

Structural Problems

Moisture has been the number one cause of structural deterioration as long as there have been structures. Moisture in all its forms—snow and ice, wind-driven rain, and water vapor—greatly affect the performance of building materials. With unwanted moisture intrusion, masonry units and mortar can crack. When water enters brick, concrete, or natural stone, thermal expansion can cause the surface to peel, pop out, or flake off—a phenomenon commonly known as spalling, which is caused by excess moisture in the masonry that exerts pressure outward. Eventually, spalling can cause large sections of the masonry to crumble and fall off, potentially leading to structural damage.

Excessive moisture also results in wall rot, an extremely unsightly and unhealthy condition, as well as in disintegration of insulation and the staining of interior finishes. Other adverse impacts include deterioration and/or corrosion of the wood/steel backup studs, cladding, ties and reinforcements which, left untreated, allow the water intrusion to increase and even spread, causing additional structural degradation or, in extreme cases, outright structural failure.

MOLD—A GROWING CONCERN

To grow, mold needs the following: oxygen; a moderate temperature, generally between 40 to 100 degrees F; a food source; and, the single most important factor, moisture, which can come from leakage from the exterior building envelope or from high indoor humidity. If there is water damage to the structure, excessive humidity, water leaks, condensation, water infiltration, or flooding, mold will grow. When airborne molds find a damp indoor haven, the spores will begin to reproduce and morph from a nuisance into a dangerous health hazard.

Toxic mold is the source of a growing number of legal battles nationwide. Yet, mold has been with us for more than 100,000 years. Why has mold recently become such an issue in the built environment? The short answer is the change in building materials. Design and construction practices can have a profound effect on the potential for mold growth. In fact, continued efforts to reduce initial construction costs have resulted in increased use of lighter and/or organic materials that may provide food for mold. Paper-faced gypsum board, for example, has been substituted for plaster and lathe, oriented strand board (OSB) for plywood, or wood boards. Instead, products such as aluminum, molded plastics, fiber cement, and foam sheathings should be utilized. Pre-finished concrete masonry units manufactured with water repellent additives will also prevent moisture penetration without any organic materials.

While the quest for energy efficiency is a worthy goal, it has inadvertently created mold-related problems. Unless properly ventilated, tighter buildings are actually an ideal environment for mold growth, as are the givens of modern life, including wall-to-wall carpeting and air conditioning, which causes condensation. Mold arises in buildings because of the lack of "big picture" design. Changes are introduced in one component material or subsystem without evaluating their impact on other aspects of a building's overall performance.

Mold can never be completely eliminated, but it can be minimized by limiting excessive moisture sources. The best formula for a mold-free building is to use a systems approach, quality materials, and a tight wall interior construction with proper operating ventilation and dehumidification systems.

Aesthetic Degradation

High on the list of aesthetic impacts of too much moisture is efflorescence, a white, powdery, crystalline deposit on surfaces of masonry, stucco, or concrete. Essentially, efflorescence is the result of a salt within the masonry unit itself that has been dissolved by excess moisture and has migrated to the surface of a porous material, where it forms that unmistakable white bloom as the water evaporates. According to the Masonry Institute, three problems must exist in order for efflorescence to occur:

1) There must be water-soluble salts present somewhere in the wall.
2) There must be sufficient moisture in the wall to render the salts into a soluble solution.
3) There must be a path for the soluble salts to migrate through to the surface where the moisture can evaporate, thus depositing the salts which then crystallize and cause efflorescence.

Even though sulfates may be present in a masonry wall, they must be dissolved by water in order to result in efflorescence. No moisture means no migration of sulfates to the surface. Certain conditions, however, will aggravate the potential for efflorescence. If the block has been exposed to cold, rainy weather during storage, for example, or to prolonged or heavy sprinkling, or if the structure has been poorly designed in terms of drainage and moisture control.

Health and Safety

According to the Department of Energy Building America Solutions Center, "Moisture is not often thought of in terms of occupant health and safety. Yet indoor air quality professionals consider moisture to be a'pollutant' that can have a significant impact on the occupants' health." Excess moisture causes the growth of bacteria, which can generate new or worsening odors and harmful gases inside the building envelope. The effects can aggravate such conditions as asthma and allergies and, in some cases, result in cancer and birth defects. Airborne moisture is ripe for dust mites and roaches whose droppings exacerbate allergies and whose appearance necessitate the use of insecticides, which have their own deleterious effects. One of the most dangerous threats to human health and welfare from excess moisture in the building is mold. The subject of widespread media coverage and a surging number of cases across the country, mold can have severe consequences, and is extremely challenging to remove. Property insurance does not cover all mold damage, and insurance companies are scaling back on coverage and are not writing new policies in some states. Liability policies are now including mold exclusions. For further information on the growth and consequences of mold, see accompanying sidebar.

PROPER MASONRY DESIGN AND INSTALLATION FOR MOISTURE MANAGEMENT

Moisture management ranks as a top priority in a wall, and appropriate design and installation techniques will go a long way to eliminating the potential for health, legal, and financial devastation caused by excessive moisture in the building envelope. While it is best to keep moisture from entering a wall in the first place, that is probably an unlikely occurrence. Modern designs are geared to thin wall construction and, to some extent, this allows buildings to leak. Besides precipitation, moisture can enter masonry walls from several different sources, including capillary action, water vapor, and groundwater. The objective is to control the water that enters a wall and provide a way for it to drain before it has a chance to do any damage or penetrate further. The National Concrete Masonry Association maintains that

successful moisture mitigation in concrete masonry walls involves several techniques, including flashing and counter flashing, weeps, vents, sealants, water repellents, post-applied surface treatments, vapor retarders, and crack control measures. All components should have redundant use, with the preferred approach to controlling moisture being a four-level line of defense, including surface protection, internal protection, and drainage and drying. The strategy here is that a wall's water tightness will still be preserved if one of these systems fails.

Detailing techniques vary by type of masonry unit. The following are three of the most common masonry scenarios:

1) Full Bed Depth Veneers: In a cavity wall, moisture control relies on gravity and an unobstructed 2-inch airspace to get water down to the flashing and the weeps. This is the basic rainscreen principle wall.

2) Single Wythe Walls: A single wythe wall is a stone, brick, or concrete wall that is one masonry unit thick. Single wythe walls offer the economic advantage of serving as the structural system with multiple finish options on the exterior and the interior. Single wythe walls do not require the backup of a traditional cavity wall construction, but in order to provide full protection from the elements they must be carefully detailed and constructed

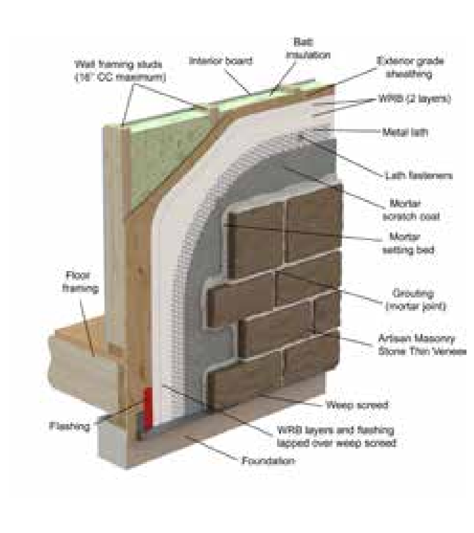
3) Manufactured Stone Thin Veneer: An increasingly popular masonry solution is manufactured thin veneer, which refers to a lightweight, flat-backed, thin surface product that is applied directly to a solid facing. Thin veneers average in thickness from 1-inch to 2-inches and, per International Code Council regulations, must weigh 15 pounds or less per square foot. Thin veneers can either be directly adhered or attached to a mounting system. According to the Masonry Advisory Council, a proper model for an adhered exterior veneer that provides adequate moisture control uses Oriented Strand Board (OSB) as sheathing on the outer face of the studs, followed by two layers of building paper. A drainage mat is then installed to drain any water that has penetrated to the flashing, which in turn sends it to the building exterior via the weepholes. Atop the drainage mat, a galvanized expanded metal lath, or diamond mesh, should be attached as it will hold the veneer to the studs. A parging backing, which is a thin coat of mortar to provide a smooth surface for masonry and seal it against moisture, should be applied onto the mesh. Mortar is applied to the back of the thin veneer and pressed on to the parged surface.

WATER-REPELLENT ADMIXTURE ADVANCES IN BLOCK AND MORTAR

An effective method in controlling moisture in the building envelope is through water-repellent admixtures. Advances in technology have enabled manufacturers to offer water-repellent admixtures in both block and mortar which, if used together, offer superior moisture control and protection against all types of moisture infiltration.

Because untreated masonry units typically absorb water through capillary suction or wicking, the anti-wicking action of an integral water repellent will minimize the amount of water absorbed, and enable any water that has breached the surface to drain toward flashing and weep holes. No film forms on the surface of the masonry as a result of the integral water repellent, nor is the admixture impervious to moisture, which means the masonry remains breathable.

Historically, three types of admixtures have been used. Calcium Stearate has demonstrated

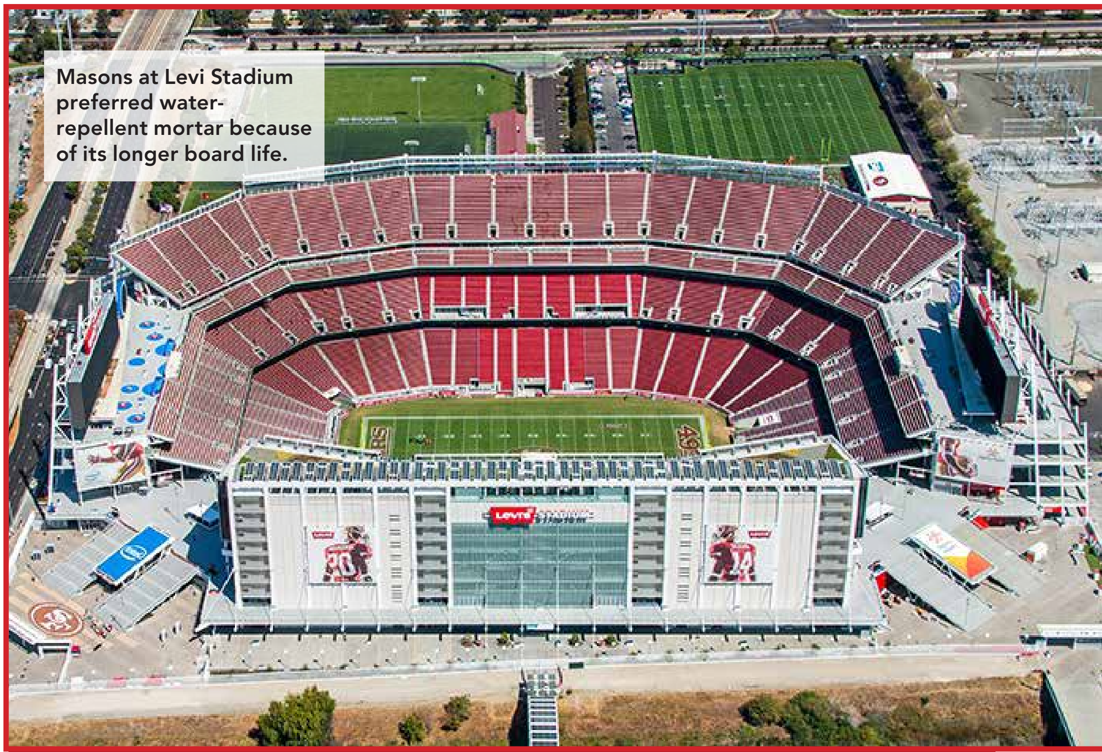


Isometric view of thin veneer in a grouted installation over wood framing.

an increase in air and a poor bond, as have the second type of admixture, tall oils. The third type, polymetric, has shown a better bond between units and mortar, though the air component has varied by manufacturer. High air content in mortar lowers the compressive strength and can reduce the bond between units. Low air content will reduce the freeze-thaw resistance of mortar. Polymeric admixtures do not alter the finished appearance of the block, nor do they affect its "paintability," but instead provide a denser, more uniform unit as well as moisture control and limited risk of efflorescence. The admixture is incorporated at the plant, ensuring even distribution throughout the concrete mix.

Especially effective in lightweight concrete masonry units and single wythe construction as added protection against water infiltration and wind-driven rain, an integrated water repellent agent assures design professionals that the product will be executed as specified and in the proper proportion for maximum protection.

While an integral water repellent in a masonry unit will go a long way to controlling moisture in a building, the joints are still susceptible to water infiltration. Consequently, use of both masonry units and mortar with an integral water repellent is necessary to provide full protection and ensure the surface is not breached by moisture in any form. Recently developed, specially engineered granulated formulas can be added to the mortar/sand during the blending process of premixed mortars, which can also improve bond strength over the service life of the building.



Masons at Levi Stadium preferred water-repellent mortar because of its longer board life.

INTEGRAL WATER-REPELLENT MORTAR A WINNER FOR LEVI STADIUM

Levi's Stadium, located in Santa Clara, California, is the home of the San Francisco 49ers, future host to Super Bowl 50 in 2016, and widely considered the "next generation" of stadium design. When it came to the construction of this new stadium, concrete masonry was chosen for its versatility, durability, and structural qualities. Pre-blended Type S mortar with an integrated water repllent was used underneath the stadium for corridors, locker rooms, storage and mechanical rooms, and even a detention area for rowdy fans. Water-repellent mortar was specified for use in the architectural ground face blocks for an exterior wall. "The masons preferred the pre-blended water-repellent mortar because it was not as coarse as other local brands and had longer board life," says Chuck Wood, estimator and project manager of Bratton Masonry of Fresno California for Levi Stadium.

Introduced in the early 1980s, integral water-repellent mortars are available in liquid and powder form, with the liquid admixture applied on site at the mixer. Powders are typically found in preblended mortars. Each type of mortar is available in Type M, S, and N compressive strengths in compliance with ASTM C270 and is engineered as a preblended mortar for consistency, workability, and yield—providing factory-controlled mixes, batch to batch, compared to field-mixed mortars. In addition to creating a superior bond, these mortars can be formulated for extended board life, eliminating retempering in hot or windy climates.

Board life is a job-site-related term used by masons to define the working time of the mortar, and for them to assure a proper application. Job site conditions such as high ambient air temperatures, sunlit walls versus walls in the shade, windy conditions, etc., may affect the board life, depending on the overall performance or water retentivity of the mortar. In the event that the board life is reduced by job site conditions, retempering, which is the addition of water to the remaining mortar in the mixer or mortar pans, is permitted once during the plastic stage. Under no circumstances should colored mortar be retempered, as the addition of water will affect the final color of the mortar.

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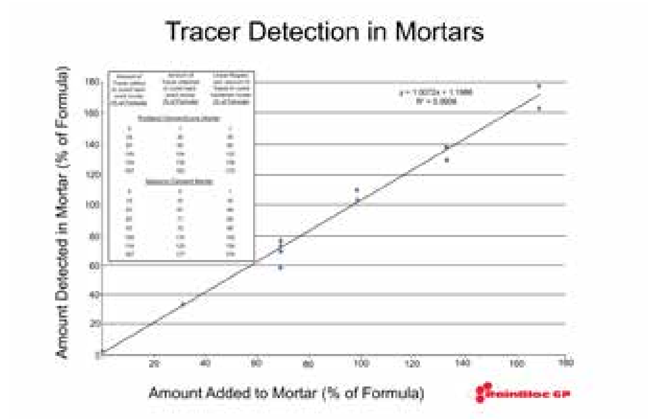
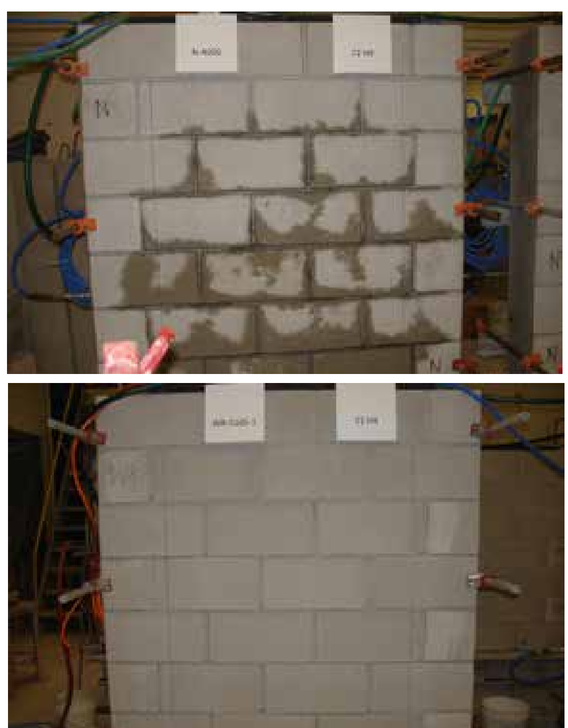


This chart shows that a water repellent can be traced in harden mortar, a unique feature of certain products that proves the right amount of admix is actually in the system.

Mortar mixes with integral water repellents have been formulated for special applications, including high-moisture environments, coastal climates, historic renovation projects, or where cement-based mortar is the preferred material.



Masonry with integral water repellent mortar after 72 hours.

Integral water repellents in mortars have several advantages over those that are site applied. An integral admixture assures accurate blending at the manufacturing facility—in short, that the water repellent will be precisely metered, properly proportioned, subject to quality control measures, and delivered as specified. Its presence is detectable and can be verified after the mortar hardens. Job site applications, on the other hand, are known to pose challenges in achieving consistency, particularly during difficult weather conditions. Site-applied water repellents have a limited surface life, too, ranging from two to seven years, and most manufacturers recommend a two-coat system, which adds to the project schedule and budget. Untreated units may become wet prior to sealing, raising the potential for moisture problems down the line. By contrast, integral water repellents enable masons to save time and costs as no measuring, mixing, or additional steps are required, eliminating the potential for job site mistakes and the need to stock and dispose of liquid admixture supplies.

Integral water repellents function well in high moisture areas.

Based on C1384 testing by the National Concrete Masonry Association, essential to demonstrate water repellency standards for mortars, the most advanced preblended mortar products have demonstrated up to an 8 percent increase in flexural strength, significantly decreased resistance to water absorption, and a nearly 50 percent longer board life than untreated mortars. Other specifications for masonry products with integral water repellents include the following:

- ASTM 91 Standard Specification for Masonry Cement
- ASTM C 150 Standard Specification for Portland Cement
- ASTM 207 Standard Specification for Hydrated Lime for Masonry Purposes
- ASTM C1714 Standard Specification for Preblended Dry Mortar Mix for Unit Masonry
- ASTM E514 Standard Test Method for Water Penetration and Leakage Through Masonry
- Meets ACI 530.1 Specification for Masonry Structures

Colored Mortar: To meet aesthetic goals, manufacturers have made colored mortar available. These products are sold as a masonry cement-based or Portland/lime-based product in more than 36 standard colors and can be color matched to other project components. Design professionals should consider incorporating architectural blocks and corresponding colored mortars as part of this integral system. Some manufacturers have their own array of colored blocks sold in a kit format—these can be used in conjunction with water-repellent masonry units to provide joint warranty wall system approaches to water repellency. Architects should note whether these products meet, or preferably exceed, ASTM C-270, and ASTM C-1384.

Colored mortar is available in a variety of colors to complement masonry units.

Delivery: It is important to note that in some cases these mortars are available in a silo delivery system. Bulk bags are often used on large, high-volume jobs where production is important, and bags weighing as much as 3,000 pounds can be loaded into a steel silo. Silo systems, capable of handling up to 30,0000 pounds of material, are widely considered to offer efficient, high-output product mixing at the job site, thereby improving productivity. Gravity silo systems do not require a power source—only a pull of the handle—and have been reported to reduce mixing times by up to 50 percent. In addition, automated batching systems and production quality controlhelp eliminate testing issues on fast-track projects. "These bulk silo systems also help reduce the amount of unused material and help reduce paper bag waste for a more environmentally friendly jobsite," says Eric Peterson, Senior Vice President for Concrete Bagged Materials at Oldcastle, noting that bulk products and silo systems help maximize product usage, thereby eliminating the piles of wasted sand associated with field-mixed product. Bulk products can dramatically reduce the amount of paper waste associated with bagged products, diverting waste that would otherwise end up in landfills.

Design professionals should confirm the compatibility of water-repellent masonry products with any system that includes the products of other manufactures—all elements should be compatible, and their collective performance and intended use verified. Consideration must be given to the means and methods of application, products used, project-specific conditions being addressed, and standardized tests performed for each proposed system or variation. It is also advisable to use approved mock ups or sample panels throughout the project process through to completion.

TRADER JOE'S GOES FOR SILO DELIVERY

Trader Joe's knows a good deal when it sees one. On past projects, water repellent was mixed into the mortar on site, which proved to be difficult and time consuming. At one Colorado store, switching to an integral water repellent improved consistency and decreased time, an advantage that, together with silo delivery, contributed to project efficiency and enabled an on-schedule project completion. Use of the silos, in fact, allowed masons to make a batch of mortar in half the time of conventional mixing, increasing productivity. The silos also eliminated labor expenses associated with bag handling, loading, and sand shoveling. Further, the silos were easy to move around the job site and kept products dry due to their weather resistance. The contractor further noted improved workability, ease of troweling, and secure attachment to the head/vertical joints with the integral water-repellent concrete. As a result of this project, all future Trader Joe's in the state of Colorado will be constructed with integral water-repellent masonry products.

Silo delivery of masonry products boosted job-site efficiency and enabled an on-time completion at a Colorado Trader Joe's store.

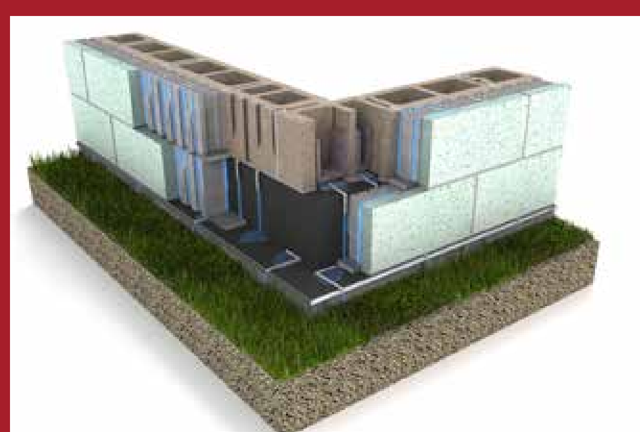
COMPLETE MASONRY SYSTEMS

Manufacturers are continually developing innovative solutions that provide architects with increased performance and aesthetic benefits coupled with ease and efficiency of installation. A systems approach that incorporates several elements is increasingly being adopted in the construction industry as these products offer considerable efficiencies as well as installation advantages and cost savings. Manufacturers are now offering complete high performance masonry systems that mitigate water penetration using water admixtures in block and mortar, and provide backup moisture management.

INTEGRATED CONCRETE MASONRY SYSTEM SCORES AT A WISCONSIN SPORTS COMPLEX

The 50-year-old Banta Bowl sports complex of Lawrence University in Appleton, Wisconsin, recently underwent a dramatic makeover. In addition to installing new bleachers, lighting, scoreboard, and an upgraded dual-sport synthetic field, the renovation also called for expansion and upgrade of the stadium's press box and, the centerpiece feature, locker room space for the Lawrence University Vikings, as well as visitors' locker rooms and spaces for officials, concessions, ticket sales, public restrooms, and storage.

Lead architect Brad Kwasny of Bray Architects, looked to an integrated concrete masonry system (ICMS) to accomplish multiple construction tasks in a single assembly. "It was one of those situations where we were looking for speed of construction within a limited space, with a limited budget," says Kwasny, referring to the system's ability to offer continuous insulation, moisture management, and wind and fire resistance, as well as interior and exterior aesthetics in one assembly by combining a structural CMU and molded insulation insert with a thin veneer face. As a complete wall system, the ICMS also offered fully insulated corners, returns, and beams to provide a 100 percent thermally broken system. In addition the R-value was approximately 20 percent higher than the R-value of traditional EPS of the same density. "Once the masons got into a rhythm of working with this new system, it installed much more quickly than the traditional way of laying the CMU, then spraying insulation, and then adding a veneer," says Kwasny. "The finished wall also took up significantly less space by reducing what would have been a 15.5-inch wall depth to 12.25 inches."



Drainage details in the wall system chosen for Banta Bowl.

The design of the ICMS allows for either standard CMU or architectural CMU on the interior with the option of a completely different architectural face on the exterior. For the Banta Bowl project, Kwasny chose painted CMU for the interior and a variety of faces, including a ground face block for the exterior.

Two such systems involve different approaches. The first approach, an insulated concrete masonry system (ICMS), is comprised of a pre-assembled structural masonry unit (CMU), molded expanded polystyrene (EPS) insulation insert and thin veneer face; it is installed as a complete assembly and is fully thermally broken. Some ICMS utilize proprietary EPS foam insulation material, which has be shown to be the best performer among rigid foams in retaining the least amount of moisture—a situation that favorably impacts thermal performance. In terms of moisture management, some closed-cell foams like EPS have a Class III Vapor Permeability rating of between 2.5 and 5.5 perms depending on thickness and density, meaning that this type of continuous insulation can more easily transport water vapor, reducing the likelihood of mold, mildew, and structural damage. Architects should investigate the water absorption rate of the material relative to traditional insulation materials. ICMS with stainless steel ties offers protection in various extreme situations. Because they do not readily corrode, rust, or stain with water as do ordinary steel anchors, stainless steel anchors can be effective in salt water or coastal environments. Another moisture protection advantage in these systems is the fact that horizontal gaskets have drainage holes to channel water down and away from the building, which is particularly useful as the building ages and water infiltrates cracks in the mortar.

"This type of insulation provides the designer with flexibility as it is adaptable in size, shape, and density, which eliminates the need to glue together multiple boards to achieve the desired insulation thickness—a characteristic that enables designers to achieve R-value targets in a thickness-constrained application," says John Cicciarelli, National Sales Manager at Oldcastle. "As codes evolve and R-value targets become ever more stringent, ICMS perhaps offer the best chance of easily adapting as a slight increase in insulation thickness can provide the necessary thermal performance."

Drainage channels built in to both sides of the foam panel control moisture by allowing it to drain down and away from the structure.

Another option is a foam panel system. Relatively new to the market, foam masonry panel systems provide continuous insulation (CI), which is important because whenever a layer of insulation is interrupted, its effective R-value is reduced. These systems consist of foam panels, stainless steel screws or anchors, masonry units, and mortar. Moisture management is built into the foam system as drainage channels on both sides of the panel divert any moisture that has penetrated the wall channel downward and away from the structure so there is no build-up of water within the panel system. While achieving integrated moisture management, these systems also attain R-value targets that create energy savings and reduce heating and cooling costs with minimum thickness. The layer of continuous insulation outside the framing yields R¬-values as high as R-13. Foam systems pay substantial dividends in other areas as well. They have been proven to resist wind speeds of more than 110 mph and, placed beneath the masonry surface, foam panels give the wall system an STC rating of 51. This is especially desirable in multifamily structures because loud sounds will only be faintly heard, leaving occupants with a quiet dwelling. In rigorous testing per NFPA 285 and ASTM E119 standards, these systems have withstood hour-long exposure to temperatures exceeding 1,700 degrees F.

One critical area where both of these systems have an advantage is installation. Proper installation is vital to the effective functioning of any wall assembly, and installing wall assemblies with numerous elements can be time-consuming, costly, and prone to error. As a single-pass installation, these all-in-one products simplify the process, eliminating the need for adding insulation, moisture management, and finishing materials—saving associated labor costs and improving accuracy.

SEALING AFTER COMPLETION—THE 110 PERCENT SOLUTION

While integral water-repellent masonry block and mortar will protect a building against water intrusion, application of a custom masonry sealer will provide an extra measure of security. One successful approach is to use a clear, solvent-based silicone elastomer formulated to weatherproof custom masonry units and related materials. However, once silicone is applied, many other products will not adhere. This type of product will penetrate and fill any pores to prevent water infiltration through exterior walls exposed to normal weathering. Architects should look to specify a sealer with UV stability and protection against graffiti, as treated surfaces are able to resist many types of graffiti and to facilitate graffiti removal. The most effective sealers will also control surface stains such as efflorescence and mildew while not trapping moisture and allowing the surface to “breathe.” The selected product should also demonstrate good surface beading.

It is important, however, to test the sealer because not all products are compatible with surface treatments that have already been applied. The appearance and wetting characteristics of surfaces intended for the sealer should be noted, and previously applied surface treatments removed. The sealer can be applied by low-pressure fan spray or by brushes or rollers made of a synthetic material. The sealer manufacturer should be consulted in the event of any questions or issues that arise.

A SYSTEMS APPROACH TO CONTROLLING MOISTURE IN MASONRY

Significant moisture intrusion on a building will have adverse structural, aesthetic, and health impacts, and it can be devastating in terms of legal and financial consequences. While all buildings leak to some extent, moisture intrusion can be controlled by the appropriate design details and in the case of masonry construction, through water-repellent admixtures within the block and the mortar. Further, new high-performance systems with such admixtures offer superior moisture management capabilities while delivering energy efficiency and ease of installation and maintenance. For added protection, a custom masonry sealer coat can be added for a “110 percent” solution.

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1. What has been the number one cause of structural deterioration as long as there have been structures?
   a. Mold
   b. Moisture
   c. Poor workmanship
   d. Shoddy building materials

ONLINE PORTION

2. When water enters brick, concrete, or natural stone, thermal expansion can cause the surface to peel, pop out, or flake off. This phenomenon is commonly known as:
   a. Efflorescence
   b. Degradation
   c. Wicking
   d. Spalling

3. The white, powdery crystalline deposit on surfaces of masonry, stucco, or concrete is known as:
   a. Spalling
   b. Salting
   c. Efflorescence
   d. Mold

4. Mold has recently become a big issue in the built environment due to:
   a. The change in building materials
   b. Global warming
   c. Poor detailing
   d. Poor indoor air quality

5. In a cavity wall, moisture control relies on:
   a. Gravity
   b. An unobstructed 2-inch airspace to get water down to the flashing and the weeps
   c. Both of the above
   d. None of the above

6. The anti-wicking action of an integral water repellent will:
   a. Maximize the amount of water absorbed
   b. Minimize the amount of water absorbed
   c. Channel the water to the flashings
   d. Guide the water downward

7. Integral water-repellent mortars are available in both liquid and powder form.
   a. True
   b. False

8. What are capable of handling up 30,000 pounds of material and widely considered to offer efficient, high-output product mixing at the job site, thereby improving productivity?
   a. Silo systems
   b. Conveyor systems
   c. On-site mixers
   d. Specially engineered delivery trucks

9. Which of the following is comprised of a pre-assembled structural masonry unit (CMU), molded expanded polystyrene (EPS) insulation insert and thin veneer face?
   a. Tracking system
   b. Tie back system
   c. Foam panel system
   d. Insulated concrete masonry system

10. Moisture management is built into a masonry foam panel system through:
   a. Drainage channels on both sides of the panel
   b. Drainage channels on one side of the panel
   c. Open-cell foam
   d. Closed-cell foam