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CLEANING CONCRETE MASONRY

TEK 8-4A
Maintenance (2005)

Keywords: abrasive cleaning, architectural masonry, chemical cleaning, cleaning, construction practices, high-pressure washing, sand blasting, water cleaning

INTRODUCTION

Concrete masonry buildings offer exceptional beauty, coupled with attributes such as structural strength, durability, fire resistance, acoustic performance and low maintenance. Proper cleaning after construction and throughout the life of the building will help preserve concrete masonry's beauty.

Although the maintenance needs of a well-designed and constructed masonry wall are minimal, contaminants can detract from an otherwise attractive structure. Cleaning of mortar smears, construction dirt and possibly efflorescence from the construction phase is usually required. Subsequent cleaning may be required over the life of the building to address dirt and soot from the atmosphere or staining from specific sources. Appropriate cleaning can remove contaminants and help produce a more uniform appearance.

This TEK discusses several general cleaning methods, applicable to whole-wall cleaning. For information on removing stains or localized contaminants, refer to *Removal of Stains From Concrete Masonry*, TEK 8-2A (ref. 7).

SUBSTRATES

The ease of cleaning a masonry wall can be affected by the concrete masonry units and mortar used in the wall. Cleaning products and techniques applicable to one masonry wall may not be appropriate for others. In addition, special consideration should be given to walls incorporating more than one material, such as a concrete masonry wall with clay masonry banding.

Concrete Masonry Units

Conventional, or nonarchitectural, concrete masonry units (CMUs) have a relatively smooth surface, formed from a thin layer of cement paste resulting from the typical concrete masonry manufacturing process. Aggressive cleaning methods may remove this layer, exposing aggregate and altering the final appearance. For this reason, any aggressive cleaning should be performed consistently across the entire wall surface for a uniform appearance after cleaning. In some cases, abrasive cleaning or pressure chemical cleaning are specified with smooth faced units to produce a slightly mottled "stone washed" appearance.

Ground faced units (also called honed or burnished) are polished after manufacture to achieve a smooth finish with the appearance of polished natural stone. Coatings, which are often used to deepen the color, can also help cleaning efforts by preventing dirt and other contaminants from penetrating the surface. When using ground faced units, every effort should be made to keep the units clean and free from mortar smears and droppings during construction. When required, these units can be resealed after final cleaning.

Other architectural CMU, such as split faced, split fluted and tumbled units have a natural stone-like texture produced during manufacture. The rough texture tends to hide minor soiling and makes these units more forgiving of minor efflorescence or other discolorations. This texture is also more suited to cleaning with abrasives, if that technique is required.

Glazed concrete masonry units are manufactured by bonding a permanent colored facing (typically composed of polyester resins, silica sand and various other chemicals) to a concrete

Figure 1—Pressure Chemical Cleaning
(photo courtesy of PROSOCO, Inc.)

masonry unit. The result is a smooth impervious surface, highly resistant to staining and easily cleaned. During construction, mortar and grout smears and droppings should be cleaned off while still easily removable, before they harden completely to the surface.

Typical Sizes and Shapes of Concrete Masonry Units, TEK 2-1A (ref. 5), contains more information on the various types of concrete masonry unit finishes.

Mortar

Choosing a mortar color close to that of the concrete masonry unit makes cleaning the wall of mortar smears easier, as the mortar tends to blend in. Mortar color should be chosen to match the unit color when smooth or ground faced units are used, as they can be difficult to clean without altering the appearance. Walls with contrasting mortar and masonry unit colors may require more aggressive cleaning to remove visible mortar.

In general, the lowest-strength mortar that will meet project requirements should be specified. Higher cement content mortars with higher compressive strengths should not be assumed to have better field performance, in fact the opposite is more often true. Mortars with lower compressive strengths tend to be easier to clean off the face of the wall than are stronger mortars. Lower strength mortars also exhibit better workability, which tends to increase quality of construction. Note that building codes may restrict the use of some mortars for particular applications. More detailed information on masonry mortars is available in TEK 9-1A, *Mortars for Masonry Construction* (ref. 4).

CLEANING DURING CONSTRUCTION

Many stains can be prevented or minimized through proper design, construction and maintenance procedures. Construction practices can greatly impact the amount of cleaning required for a newly constructed wall. For example, proper grouting procedures can help prevent grout blowouts and the associated clean up. Keeping the masonry as clean and dry as possible during construction can allow for less aggressive cleaning methods when construction is complete.

Cleaning exposed concrete masonry during construction encompasses such issues as the control of efflorescence and of mortar and grout droppings and smears. Detailed information on construction practices that minimize efflorescence are discussed in *Control and Removal of Efflorescence,* TEK 8-3A (ref. 1). The following are recommended practices for minimizing mortar and grout stains during construction (refs. 3, 6):

- ☐ Mortar squeezed out of mortar joints as units are placed should be cut off with the edge of the trowel, and care should be taken that the mortar doesn't fall onto the wall surface or smear the surface as it falls off.
- ☐ When mortar does land on or smear the surface of the concrete masonry unit, it should be removed after initial set. Walls should be cut and brushed clean before scaffolding is raised.
- ☐ Do not cut mortar tags off until the mortar is thumbprint hard, particularly on split faced units. Similarly, joints should not be tooled until thumbprint hard.
- ☐ Mortar droppings which adhere to the exposed face of the units can be removed with a trowel or chisel after being allowed to harden. Any remaining mortar can then be removed with a stiff fiber or bristle brush.
- ☐ Excess mortar should be periodically removed from scaffolding.
- ☐ Grout spills should be immediately removed by washing and brushing.
- ☐ The base of the wall should be protected from splashing mud and mortar and grout droppings by spreading plastic sheets 3 to 4 ft (914 to 1,219 mm) on the ground adjacent to the wall and 2 to 3 ft (609 to 914 mm) up the face of the wall.

In addition to these recommendations, newly constructed masonry should be protected when adjacent construction procedures may splatter or otherwise stain the masonry. For example, plastic should be placed over masonry when concrete is poured nearby and when curing agent is sprayed.

PLANNING THE CLEANING PROCEDURE

The cleaning agent and procedure should be carefully planned, based on the type of contaminant and desired results. The cleaning method chosen should be the least aggressivethat will effectively clean the wall. Before cleaning, ensure that mortar joints are cured, so the cleaning does not damage them.

Cleaning methods may alter the appearance of the finished masonry; typically, at least some cement paste is removed from the surface of the units. When this happens, more aggregate is exposed to view, which can alter the color. In general, the more aggressive the cleaning method, the more paste is removed and the greater the potential for altering the wall's appearance. For example, sandblasting can be expected to alter the appearance to a greater degree than cleaning by hand with detergent and water. Note also that the same cleaning method may have different results based on the specific procedures used. Sandblasting at a lighter pressure will produce different results from sandblasting at a higher pressure. Again, the mildest cleaning method that will satisfy should be chosen.

The cleaning agent and procedures should first be used on a sample panel or inconspicuous location to assess: their effectiveness for the type of contaminant being removed; their effect, if any, on the finished masonry appearance; as well as the agreed upon level of cleanliness. After cleaning, the sample panel should be viewed from a distance of 20 ft (6,096 mm) under diffused lighting to evaluate the results.

Whichever cleaning method is chosen, it is important that all of the masonry be cleaned in the exact same manner (including dilution rate, brushing/scraping method, dwell time, reapplication, rinse procedure, etc.) to maintain a uniform appearance. Similarly, care should be taken to avoid overlap of areas being cleaned, as this may lead also to a nonuniform appearance.

Materials such as glass, metal, wood, architectural concrete or concrete masonry and any landscaping adjacent to the area to be cleaned should be adequately protected, since they may be damaged by contact with some stain removers or by physical cleaning methods. The level of protection and area requiring protection vary with the cleaning method, so the cleaning agent manufacturer's recommendations should be followed.

If a surface water repellent is specified for the wall after cleaning, it should be applied as soon as conditions allow to minimize further moisture absorption or soiling.

CLEANING METHODS

The methods of cleaning concrete masonry can generally be divided into four categories: hand cleaning, water cleaning, abrasive cleaning and chemical cleaning (ref. 2). Cleaning by any method should be performed on an inconspicuous section of the building or a sample panel to ascertain its effect.

Hand Cleaning

Simple hand tools such as a trowel, chisel, stiff bristle or fiber brush, abrasive block or broken piece of masonry are first used for cleaning during construction. Steel-wire brushes should not be used because they can leave behind metal particles that may rust and stain the masonry.

Water Cleaning

Water cleaning involves scrubbing with water and detergent, water soaking, steam cleaning or pressure washing. When using water cleaning methods, the amount of water used should be limited to the least amount that will effectively clean the wall, as any water that enters the wall may promote efflorescence. See *Control and Removal of Efflorescence,* TEK 8-3A (ref. 1), for more detail.

Unpainted walls can usually be cleaned by scrubbing with water and a small amount of detergent. This is a nonaggressive cleaning method that generally does not alter the masonry appearance. It may not be cost-effective for large areas, however, due to the labor involved.

Clay or dirt should first be removed with a dry brush. Steel-wire brushes should not be used because any metal particles left on the masonry surface may rust and stain the masonry. Nonmetal brushes such as stiff fiber or nylon are preferred.

Soaking with water causes dirt deposits to swell, loosening their grip on the underlying masonry and allowing them to be flushed away with water. Again, this method may not be appropriate if efflorescence is the primary concern.

Heated water is useful on greasy surfaces or during cold weather. However, when used with alkaline chemicals, warm water should not exceed 160^{o}F (71^{o}C). There is no significant advantage to using hot water with acid cleaners (ref. 2).

Pressure washing equipment can be effective for surface cleaning, and is often specified for masonry restoration work to avoid the use of harsh chemicals. Water pressure should be kept to a minimum to avoid driving water into the wall which can cause efflorescence. Note that high pressures can damage masonry or alter the final appearance. Using a consistent pressure and maintaining a set distance from the wall will produce the most uniform results. If high pressure cleaning is used, it is recommended that:

a) the pressure be limited to 400 to 600 psi (2.76 - 4.14 MPa),
b) a wide flange tip be used, never a pointed tip,
c) the tip be kept at least 12 in. (305 mm) from the masonry surface, and
d) the spray be directed at a 45^o angle to the wall (never perpendicular to the wall). Pressure washing can also be used as an adjunct to scrubbing. The mild agitation created by brush application improves the overall cleaning results and enables the rinsing pressure to be kept to a minimum.

Steam cleaning has been virtually supplanted by pressure washing. However, by supplementing heat to the water, the action of loosening and softening dirt particles and grease is improved, allowing them to be more easily rinsed away. Steam is normally generated in a flash boiler and directed toward the wall using a wand at a pressure of 10 to 80 psi (69 to 552 kPa), depending on the equipment used. Although steam cleaning is less aggressive than pressure washing, it is also slower.

Chemical Cleaning

Many proprietary cleansing agents are available for concrete masonry; the concrete masonry manufacturer can be consulted for recommended compatible products. Premixed chemicals eliminate many potential problems, such as those associated with mixing reactive chemicals. They are also mixed in the proper proportions to be safely used on masonry. Strict adherence to the manufacturer's directions is required, to protect both the user and the masonry, and to avoid any potentially harmful runoff.

When used in conjunction with water washing techniques, chemical surfectants help dissolve contaminants and allow them to be washed away during the final rinsing process. If chemical cleaning agents are used, the surfaces to be cleaned must be thoroughly prewetted with low water pressure (maximum 30 to 50 psi, 207 to 345 kPa), cleansing agents must be diluted as directed by the manufacturer and the application pressures should be kept to a minimum. After application of the cleansing agent, the wall should be thoroughly rinsed with fresh water (preferably at low pressure), or if necessary at high pressure using the precautions discussed in the *Water Cleaning* section.

Chemical cleaning can be a more aggressive method than pressure washing and is often more efficient and cost effective. With proper technique, the results are uniform across the wall, although the wall's final appearance can be changed by using this method. Apply chemical cleaning solutions with low pressure spray (less than 50 psi, 345 kPa) or soft-fibered brushes.

Chemical cleaning solutions can be used to clean concrete masonry without damaging the surface; avoid using raw or undiluted acids. Even diluted acids should be used with caution, and only after thoroughly prewetting the wall, as acids dissolve the cement matrix at the masonry surface and can also damage any integral water repellent at the surface. This leaves the face more porous and exposes more aggregate, thereby changing the color and texture of the masonry. In the case of masonry with an integral water repellent, acids can also reduce the water repellency at the surface. Acids should never be applied under pressure. As a guideline, any cleaner with a pH below 4 or 5 should be considered to be acidic in nature. In addition, highly alkaline products require an acidic neutralizing afterwash as well as thorough rinsing; efflorescence can be an unwanted result if there is residual alkali.

Abrasive Cleaning

Abrasive cleaning is the most aggressive cleaning method, as the objective is not to wash away surface contaminants, but to remove the outer portion of the masonry in which the stain is deposited. For this reason, it should not be used on ground faced units, where the surface is smooth and polished. Although abrasive cleaning includes methods such as grinding wheels, sanding discs and sanding belts, it typically refers to grit blasting, also called sandblasting. Note that the use of silica sand is restricted in some areas due to its classification as an irritant, but many other blasting media are available.

Because it is a dry process, sandblasting will not promote efflorescence and can be performed in cold weather. As with pressure chemical cleaning, the cleaning method produces a consistent result across the wall with proper technique.

Care must be exercised when using abrasive cleaning techniques since overzealous applications can cause drastic changes to the appearance, durability and water tightness of the masonry. Sandblasting can alter the appearance of the masonry by roughening the surface or exposing aggregate. This is less of a concern with split faced units. In some cases, sandblasting can accelerate deterioration by increasing surface porosity. Pretesting using a sample panel is critical when sandblasting is considered.

To minimize potential damage, softer abrasives such as crushed corn husks, walnut shells or glass or plastic beads can be used. This process, sometimes called micro-peening, is slower and more costly and generally is not applicable to large scale cleaning operations.

Protective equipment and clothing must be used, including an approved respirator under a hood. Most of the dust that accompanies a dry sandblasting process can be eliminated by introducing water into the air-grit stream at the nozzle. However, the smaller particles remain a health hazard, so the same protective equipment and clothing are needed as for the dry process. The wet process requires the extra step of rinsing down the cleaned surface after blasting.

Sandblasting removes any previously applied water-resistant surface coatings, so these will need to be reapplied after abrasive cleaning.

CONCLUSION

Concrete masonry units are available in a variety of finishes, including ground faced, split faced and glazed. Contaminants from construction, such as mortar smears, and from the atmosphere after years of exposure can mar the otherwise attractive appearance of concrete masonry buildings. Cleaning methods that have been effective include hand cleaning and the use of water, chemical solutions and abrasive blasting. Some CMU manufacturers provide cleaning recommendations; in other cases, a knowledgeable professional may help determine how cleaning should best be accomplished. Field testing of cleaning materials and techniques helps ensure the desired results.

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REMOVAL OF STAINS FROM CONCRETE MASONRY

TEK 8-2A

Maintenance (2005)

Keywords: abrasive cleaning, acid wash, architectural masonry, chemical cleaning, cleaning, high-pressure washing, maintenance, stain removal

INTRODUCTION

With the continued use and expanding applications of architectural concrete masonry, segmental retaining wall units, and concrete pavers, exposed concrete masonry is becoming common across the country. Although maintenance of a well-designed and constructed masonry wall is minimal, inadvertent staining from oil, grease, or other foreign substances can destroy the appearance of an otherwise attractive unpainted masonry structure. This publication provides information on effective methods for removing some of the most common stains.

STAIN PREVENTION

Many stains can be prevented or minimized through proper design, construction, and maintenance procedures. For instance design details that prevent or reduce water intrusion reduce the chance that efflorescence will occur – see *Maintenance of Concrete Masonry Walls*, TEK 8-1A (ref. 1).

During construction of exposed concrete masonry, minimize mortar and grout smears on the face of the units. Mortar droppings which adhere to the exposed face of the units can be removed with a trowel or chisel after being allowed to harden. Any remaining mortar can then be removed with a stiff fiber brush. Also, the base of the wall should be protected from splashing mud and mortar droppings by spreading plastic sheets 3 to 4 feet on the ground and 2 to 3 feet up the wall. Covering the tops of unfinished walls at the end of the workday prevents rain from entering the wall and thus reduces the chance of efflorescence forming on the wall. Covers should be draped at least two feet down each side of the wall and a method provided to hold them in place. See *Cleaning Concrete Masonry*, TEK 8-4A (ref. 6) for more information on cleaning concrete masonry during construction and further information on cleaning concrete masonry.

PLANNING AND PRECAUTIONS

The cleaning procedure should be carefully planned. No attempt should be made to remove a stain until it is identified and its removal agent determined. If the staining substance cannot be identified, it is necessary to experiment with different methods on an inconspicuous area. The indiscriminate use of an inappropriate product or the improper application of a product may result in spreading the stain over a larger area or in causing a more unsightly, difficult to remove stain. Removing stains from concrete masonry sometimes can leave the treated area lighter in color than the surrounding area because surface dirt has been removed along with the stain or the surface has become slightly bleached. This is particularly true for buildings that are several years old. This may necessitate treating the entire wall. Materials such as glass, metal, wood or architectural concrete or concrete masonry adjacent to the area to be cleaned should be adequately protected since they may be damaged by contact with some stain removers or by physical cleaning methods.

Many chemicals can be applied to concrete masonry without appreciable injury to the surface, but strong acids or chemicals with a strong acid reaction definitely should be avoided. Even weak acids should be used only as a last resort as it dissolves the cement matrix of the masonry beginning at the surface. This leaves the face more porous so that it absorbs more water and exposes more aggregate thereby changing the color and texture of the masonry.

CLEANING METHODS

The methods of cleaning concrete masonry can generally be divided into three categories water cleaning, abrasive cleaning, and chemical cleaning (ref. 2).

Water Cleaning

Water cleaning includes the use of water soaking, steam cleaning and pressure washing. Cleaning of unpainted walls can usually be accomplished by scrubbing with water and a small amount of detergent. Clay or dirt first should be removed with a dry brush. Steel-wire brushes should not be used because they can leave metal particles on the surface of

Table 1—Materials for Stain Removal and Procedural Sequences

Stain	Appearance	Material required: Chemicals and detergents[1]	Material required: Poultice materials	Procedural sequence (see Table 2)
Aluminum	White	10% hydrochloric acid[2]	—	A-C-E
Asphalt (molten)	Black	1. Ice 2. Scouring powder	—	F B
Asphalt (emulsified)	Black	Scouring powder	—	B
Asphalt (cutback)	Black	1. Kerosene, carbon tetrachloride or benzene[3] 2. Scouring powder	Talc or whiting —	G-H B-H
Beverages-coffee, tea, cola	Tan/brown	Hot water and soap or 1% sodium hypochlorite or 25% glycerine or trichloroethylene	— — — Talc	C-D C-D J-D G-D
Blood	Reddish brown	3% hydrogen peroxide or trisodium phosphate[4]	—	C-D
Copper/bronze	Green/brown	1 part ammonium chloride or ammonium hydroxide as needed for paste	4 parts talc	G-H
Creosote	Brown	1. Kerosene, carbon tetrachloride or benzene[3] 2. Scouring powder	Talc or whiting —	G B
Dirt/pollution	Dark/oily	Water or 5% hydrochloric acid[2] or proprietary cleaner	—	B A-C-E V
Efflorescence (see also TEK 8-3A) (ref.2)	White	None or water or 10% hydrochloric acid[2]	—	N P-B A-C-E
Graffiti (see also TEK 8-4) (ref.6)	Varies	Proprietary cleaners or high-pressure washing or abrasive cleaning	—	V — —
Ink (ordinary)	Blue	Sodium perborate	Whiting	K-G-H-I
Ink (containing Prussian blue)	Blue	Ammonium hydroxide or strong detergent solution	—	J
Ink (containing indelible synthetic dyes)	Varies	Sodium perborate or sodium hypochlorite or calcium hypochlorite or ammonium hydroxide or sodium hypochlorite or calcium hypochlorite	Whiting —	K-G-H K-J
Ink (containing silver salt)	Black	Ammonium hydroxide	—	J-H
Iodine	Brown	None or Denatured alcohol	— Whiting	N M-G-B

Table 1 (cont.)—Materials fo

Stain	Appearance	Che
Iron/rust	Brown/yellow	1 part amm 6 part 7 part Same hyd
Linseed oil	Dark grey	1 part 1 part Stron
Lubricating oil or grease that has penetrated	Dark	1. Tri 2. Ke tet
Mildew	Dark/green	1 part 3 part phosp hypoc water
Moss/plant growth	Varies	Amm sodiu
Mortar smears	Grey	
Paint (dry)	Varies	Comm or ben 10%
Paint (fresh)	Varies	Trisod comm
Perspiration	Brown/yellow	Trichl
Smoke/fire	Brown/black	Scour sodiu trichlo
Soot	Black	Scour
Tobacco	Brown	1% so
Wood (rotten)	Brown	1. 1 p pa 2. Co fo

1. Numbers indicate that materials are
2. Hydrochloric acid is very toxic and
resort. For architectural or colored
3. Benzene has been found to be carc
4. Mix 2 lbs. (0.91 kg) of trisodium ph

or Stain Removal and Procedural Sequences

Material required		Procedural sequence (see Table 2)
micals and detergents[1]	Poultice materials	
t sodium or monium citrate ts water ts glycerine or	Whiting or diatomaceous earth	K-G-H-D
as above plus sodium rosulfite for step O	same	L-G-O-D
t trisodium phosphate t sodium perborate g detergent / hot water	Lime, whiting, or talc	T-L-G-D-H
sodium phosphate[4] rosene, carbon trachloride or benzene[3]	— Talc or whiting	P-L-C G-D
t of laundry detergent, ts of trisodium phate, 32 parts sodium chlorite and 96 parts of	—	M-C-D
onium sulfamate or m hypochlorite	—	R
—	—	Q
merical paint remover nzene[3] or hydrochloric acid	Talc or whiting —	V G-H S-P-A-C-E
dium phosphate nerical paint remover	—	T-C-D V
loroethylene	Talc	U-G
ring powder or m hypochlorite or oroethylene	— — Talc	B M-C-D U-G
ring powder	—	B
odium hypochlorite	Talc	H-G-D
part glycerine to 4 rts water ontinue with procedure or smoke above	—	C

e to be used in sequence.
d corrosive to concrete products; use only as the last
masonry, reduce concentration to 1 - 2%.
cinogenic. Do not breathe fumes.
osphate to 1 gal. (3.8 l) of water.

CAUTION:

Most of the chemicals listed in this publication are toxic, carcinogenic, flammable, or generally hazardous and require adequate safety precautions. Skin contact and inhalation must be avoided. As a general precautionary rule, safety goggles and rubber or plastic gloves and clothing (i.e., rain gear) should be worn. If not used outdoors, adequate ventilation must be provided. Respirators (air supply) or gas masks with an organic vapor canister and full faceplate should be used with highly toxic, vaporous chemicals. Storage and handling instructions printed on the container labels should be followed. Unused portions that have been taken from the original containers should be discarded; they should never be put back into the original containers. Chemicals should never be stored in unidentified containers (ref. 4). Many proprietary cleaners are available that are safer to both the user and the masonry than some listed herein. Consult the concrete masonry manufacturer for recommended compatible products.

Table 2—Procedure for Stain Removal

Key	Procedural sequence
A	Thoroughly prewet masonry before application
B	Scrub with brush and water
C	Scrub with brush and chemicals or detergents
D	Rinse thoroughly with clear water
E	Flush with water within 10 minutes after applying chemical
F	Cool until brittle. Chip away with chisel
G	Stir solids and liquid into thick paste, apply to stain to a thickness of ¼ to ½ inch. After poultice dries, brush or scrape off. Use wood scraper if block has tile like finish
H	Repeat as needed
I	If brown stain remains, treat as for iron stain
J	Bandage with saturated cloth or cotton ball
K	Dissolve solid chemical in hot water
L	Dissolve solid chemical in water
M	Apply liquid to surface by brush
N	Allow stain to disappear by aging
O	Put paste on trowel. Sprinkle crystals on top of paste. Apply to surface so crystals are in contact with block
P	Scrape or brush any solidified matter off surface
Q	Let harden. Remove large particles with trowel or chisel
R	Let stand. Remove with scraper and stiff bristle brush
S	Allow to age three days
T	Absorb with soft cloth or paper towels, then scrub vigorously with paper towels
V	Follow manufacturer's directions
W	Pour into paste and mix

the masonry that later may rust and stain the masonry. Non-metal brushes such as stiff fiber or nylon are preferred. Soaking with water causes dirt deposits to swell, loosening their grip on the underlying masonry and then allowing them to be flushed away with water. Some efflorescence can be removed when it first appears by dry brushing followed by flushing with water. More extensive efflorescence may require brushing with acid - see the section on chemical cleaning or *Control and Removal of Efflorescence,* TEK 8-3A (ref. 3).

Heated water is useful on greasy surfaces or during cold weather. However, warm water when used with alkaline chemicals, should not exceed 160°F (71°C). There is no significant advantage to using hot water with acid cleaners (ref. 2).

Steam cleaning virtually has been supplanted by improved and innovative pressure washing equipment. However, by supplementing heat to the soaking with water, the action of loosening and softening of dirt particles and grease is improved allowing them to be more easily rinsed away. The steam is normally generated in a flash boiler and directed toward the stain by means of a wand at a pressure of 10 to 80 psi depending on the equipment used. A drawback with steam cleaning is that is rather slow when compared to pressure washing. An advantage of steam cleaning is that it essentially leaves the concrete masonry surface intact.

High-pressure washing equipment can be extremely effective for restorative cleaning of older masonry; however, when improperly applied, it can cause severe damage. If pressure application of chemical cleaning agents is considered, the surfaces to be cleaned must be thoroughly prewetted, cleansing agents must be prediluted, and the application pressures should be kept to a minimum. High-pressure washing, however, should not be mistaken as a total replacement for hand labor. The mild agitation created by brush application improves the overall cleaning results while enabling rinsing pressure to be kept to a minimum.

Abrasive Cleaning

The objective in abrasive cleaning is not to dissolve and wash away the stain, but to remove the outer portion of the masonry in which the stain is deposited. Included in this category are grinding wheels, sanding discs, sanding belts, and the more popular grit blasting. Silica sand in recent years has been replaced as the abrasive blasting material by other products such as crushed slag in the concern over health hazards posed by airborne silica dusts. Protective equipment and clothing must be used, including an approved respirator under a hood.

Care must be exercised when using abrasive cleaning techniques since over zealous applications can cause drastic changes to the appearance, durability, and water tightness of the masonry. To minimize this, softer, less damaging abrasives such as crushed cornhusks, walnut shells, glass beads, etc. can be used on more delicate surfaces. This process, sometimes called micro-peening, is slower and more costly and generally is not applicable to large scale cleaning operations.

Most of the dust that accompanies the dry process can be eliminated with wet abrasive cleaning by introducing water into the air-grit stream at the nozzle. However the smaller, harmful particles remain a health hazard so the same protective equipment and clothing are needed as for the dry process. The wet process requires the extra step of rinsing down the cleaned surface after blasting.

Needless to say, previously applied waterproofing agents are removed during the abrasive cleaning process. Therefore, they need to be reapplied after abrasive cleaning.

Chemical Cleaning

The popularity of chemical cleaning techniques has increased substantially in recent years. When used in conjunction with one of the water washing techniques previously described, chemical solvents dissolve staining materials and allow them to be washed away during the final rinsing process.

Many proprietary cleansing agents for removal of stains are available today. They are generally much safer for the user in that the chemicals are premixed so there virtually is no danger of mixing reactive chemicals and also for the masonry in that they are mixed in the proper proportions. Strict adherence to the manufacturer's directions is still required, however, as improper use can still pose danger to both the user and the masonry. For the most part, products suitable for concrete are suitable for concrete masonry and can be found at most construction specialty and automotive supply centers and at hardware or paint stores.

Tables 1 and 2 provide information covering the removal of many common materials that stain. Table 1 describes the chemicals, detergents, or poultice materials recommended for a particular stain. Table 1 also provides letter keys which indicate steps to be followed in the removal of the stain identified in Table 2.

A poultice is a paste made with a solvent or reagent and a finely powdered, absorbent, inert material used to keep stains from penetrating deeper or spreading. It also tends to pull the stain out of the pores. Enough of the solvent or reagent is added to a small quantity of the inert material to make a smooth paste. The paste is spread in a ¼ in. to ½ in. (6 to 13 mm) thick layer onto the stained area and allowed to dry. The solvent dissolves the staining substance and absorbs it into the poultice and is left as a loose, dried powdery residue that can be scraped or brushed off (ref.4). This process frequently takes several applications to remove the stain.

CHEMICAL SUBSTANCES

The following text provides general information on the chemicals and cleaning agents referenced in Table 1 (ref. 5). As with any chemical, refer to the chemical's Material Safety

Data Sheet and always follow label directions.
Ammonium Chloride (Other names: Amchlor, chloride of ammonia, darammon, salammonite)
Odorless white crystalline substance used in some agricultural processes. Available from chemical and dry-cleaning supply centers and hardware stores.
Hazards: Toxic and corrosive.

Ammonium Citrate (Other names: Citric acid, diammonium salt)
White odorless substance in either granular or crystalline form. Found at supermarkets and hardware stores.
Hazards: Corrosive and flammable.

Ammonium Hydroxide (Other names: Ammonia solution, ammonia water, household ammonia)
A colorless liquid with a strong irritating odor. Found at most supermarkets and hardware stores.
Hazards: Toxic.

Ammonium Sulfamate (Other names: Amicide, ammonium amidosulphate)
A white crystalline substance commonly used as a weed killer. Found at chemical and garden supply centers.
Hazards: None.

Benzene (Other names: Benzol, benzole, coal naptha)
An excellent solvent and colorless liquid with characteristic odor and burning taste. Found at automotive, chemical and dry cleaning supply centers and hardware and paint stores.
Hazards: Violently flammable and carcinogenic

Calcium Hypochlorite (Other names: B-K Powder, losantin, pool chlorine)
White in powder, granule, or pellet form used to kill algae, fungus, and bacteria. Found in pool chemical and garden supply centers.
Hazards: Corrosive to flesh and flammable when in contact with organic solvents.

Carbon Tetrachloride (Other names: Perchloromethane, tetrachloromethane)
A nonflammable, clear, poisonous liquid used in fire extinguishers and as a solvent. Available at chemical, dry cleaning, and pharmaceutical supply centers, and paint stores.
Hazards: Toxic.

Glycerine (Other names: Glycerol, glycyl alcohol)
An odorless, colorless, syrupy liquid prepared by the hydrolysis of fats and oils. Found at chemical, pharmaceutical, photographic, and printer supply centers.
Hazards: Flammable.

Denatured Alcohol (Other names: Methylated Spirit)
Found at pharmaceutical and printer supply centers and hardware stores.
Hazards: Toxic and flammable.
Hydrochloric Acid (Other names: Muriatic acid)
A strong, highly corrosive acid commonly used for cleaning metals and balancing the pH of swimming pools. It can be found at swimming pool supply centers, chemical supply centers and hardware stores.
Hazards: Toxic, very corrosive to flesh and concrete materials. Reacts vigorously with ammonia and detergents containing ammonia. Use extreme caution when handling and applying. Never use full strength. Dilute by adding acid to water, never water to acid. Rinse thoroughly within 10 minutes after applying.

Hydrogen Peroxide (Peroxide of hydrogen)
A colorless, syrupy liquid used as a bleaching and disinfectant in low concentrations and as a rocket fuel in higher concentrations. Available at chemical supply centers, drug stores, supermarkets, and hardware stores.
Hazards: None in the normal 3% solution. Toxic, corrosive to flesh and flammable in higher concentrations.

Sodium Citrate (Other names: Citrate of soda, trisodium citrate)
White odorless substance in crystalline, granular, or powder form. Commonly used as a neutralizing buffer in chemical research. Available from chemical supply centers and drug stores.
Hazards: None.

Sodium Hydrosulfite (Other names: Hydrolin)
White powder with little odor. Commonly used in industrial cleaners. Found at chemical supply centers.
Hazards: Very toxic when in contact with moisture.

Sodium Hypochlorite (Other names: Clorox, hypochlorous acid, household bleach)
Faint yellow to clear liquid with chlorine smell. Available at supermarkets.
Hazards: Corrosive to flesh.

Sodium Perborate (Other names: Perboric acid, perborax, sodium salt)
White, odorless, crystalline powder commonly found in "all-in-one" laundry detergents and some dishwashing powders. Available at chemical and pharmaceutical supply centers and supermarkets.
Hazards: Toxic and flammable when in contact with organic solvents.

Trichloroethylene (Other names: TCE, ethynyl trichloride)
Colorless liquid with chloroform smell found in common cleaning solvents. Available at automotive, chemical, dry cleaning, paint, photographic, and printer's supply centers.
Hazards: Highly toxic and can react with strong alkalies in fresh mortar or concrete to form dangerous gases.

Trisodium Phosphate (Other names: Sodium orthophosphate, TSP, phosphate of soda)
A crystalline, white, odorless compound found in household cleaning detergents such as "Spic and Span". Available at supermarkets and hardware stores.
Hazards: Corrosive to flesh

MATERIALS FOR POULTICES

The main properties desired in the powdered materials used to make poultices are: 1) grains sufficiently fine so the paste will hold plenty of liquid; 2) enough range in particle size so they will make a smooth, readily moldable paste; and 3) chemical inertness to the chemicals with which the powdered material is used. The last precludes using portland cement in combination with water, although it can be used with organic liquids. For the same reason, if acids are to be used, the paste must not be made with whiting (calcium carbonate), ground limestone, hydrated lime, or portland cement. Otherwise, the finely divided materials are more or less interchangeable.

Diatomaceous Earth (Other name: Diatomite, filter media, fuller's earth)
Available at swimming pool supply centers.

Lime (Other names: Calcium hydroxide, caustic lime, mason's lime, quicklime)
Available at building material supply centers and nurseries.

Portland Cement (Other names: Cement)
Found at building material supply centers and ready mixed concrete plants.

Talc (Other names: Talcum powder)
A very soft mineral that is a basic silicate of magnesium, has a soapy feel, usually white in color, and is used especially in making talcum powder. Available at supermarkets and drug stores.

Whiting (Other names: Calcium carbonate, baking powder)
Found in nature as calcite and aragonite and in plant ashes, bones and shells. Available at supermarkets and nurseries.

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CONTROL AND REMOVAL OF EFFLORESCENCE

TEK 8-3A
Maintenance (2003)

Keywords: cleaning, efflorescence, maintenance, stain removal

INTRODUCTION

Efflorescence is a deposit of soluble salts and bases, usually white in color, that sometimes appear on the surfaces of masonry or concrete construction. Although it may be an aesthetic concern, efflorescence will not affect structural performance.

Often efflorescence is apparent just after the structure is completed. If the efflorescence is essentially uniform throughout the exterior facade, it indicates normal water loss from the materials and the building. Some identify this occurrence as "early age" efflorescence or "new building bloom". If unattended, the salts will eventually be removed by rain water.

If the deposit is heavy and essentially shows as white streaks immediately below mortar joints or covering localized areas of the masonry, it indicates that water has entered or is entering the wall at a higher elevation. These salts are called leachates, referred to "lime spots", "lime runs" and "lime deposits"; and are sometimes identified as "late age" or recurrent efflorescence. Late age or recurrent efflorescence usually consists of more permanent surface accumulations and indicates a need for corrective measures.

This TEK discusses the various mechanisms which cause efflorescence and presents recommendations for its control and removal.

CAUSES OF EFFLORESCENCE

A combination of circumstances causes efflorescence. First, there must be soluble compounds in the masonry. Second, moisture must be present to pick up the soluble salts and carry them to the surface. Third, some force—evaporation or hydrostatic pressure—must cause the solution to move. If any one of these conditions is eliminated, efflorescence will not occur.

Source of Salts

The individual elements and compounds associated with efflorescence may be present in concrete masonry units, mortar and grout. However, efflorescence of masonry is generally attributed to water soluble sodium, potassium and calcium. These solutions either precipitate as hydroxides or combine with atmospheric carbon dioxide and sulfur trioxide. The compounds produced by the combination of these elements are white or yellow salts, all of which are less water soluble than their former hydroxide counterparts. Chlorides are usually a result of contamination of masonry units and sand by sea water or runoff from alkaline soils. Since chloride salts are highly soluble in water, rain will often wash them off.

The amount and character of the deposits vary according to the nature of the soluble materials and the atmospheric conditions. Efflorescence is particularly affected by temperature, humidity and wind. In the summer, even after long rainy periods, moisture evaporates so quickly that comparatively small amounts of efflorescence are brought to the surface. Thus, efflorescence is more common in the winter when a slower rate of evaporation allows migration of salts to the surface. In spring, condensation frozen within the masonry may be released by warm weather allowing for further solubilizing of compounds and their migration to the surface. With the passage of time, efflorescence becomes lighter and less extensive unless an external source of salts or recurrent water migration is present.

In most cases, compounds that cause efflorescence are water soluble and are left on the surface as the water containing them evaporates. Sometimes, however, chemicals in the construction materials react with chemicals in the atmosphere to form the efflorescence. In the case of concrete masonry or mortar, the hydrated cement contains some calcium hydroxide (soluble) as a product of the reaction between cement or lime and water. When this calcium hydroxide is brought to the surface by water it combines with carbon dioxide in the air to form calcium carbonate (slightly soluble), which then appears as a whitish deposit.

Cements used in the production of mortar and concrete masonry units contain small amounts of water soluble compounds of sodium and potassium. Such water soluble alkalis, present as only a few tenths of one percent, can appear as efflorescence when leached out of the masonry by migrating moisture and concentrated at some point on the surface.

In addition to the masonry materials, building trim such as concrete copings, sills and lintels may also contain considerable amounts of soluble compounds. Some admixtures or ground water may also contribute to efflorescence. Most admixtures are proprietary and their compositions are not disclosed. Accordingly, the efflorescence potential of such admixtures should be determined by experience or laboratory tests. Dispersing agents used in pigments may increase the potential for efflorescence.

Sources of Moisture

Water serves as the vehicle by which soluble salts and bases are transported to the surface, where they accumulate as the water evaporates. The primary source of moisture is rain water. Rain water may enter the wall through one or more of the following paths—permeable masonry units, partially filled mortar joints, inadequate flashing and sealing details, and cracks or other openings in the wall.

Considerable moisture may also enter a masonry wall as vapor from the interior of a building and accumulate within the wall as it condenses. Excessive accumulation of condensed water vapor may lead to efflorescence.

A third source of moisture that may contribute to the future formation of efflorescence is water that enters the masonry during construction. Improper protection of masonry during and after construction can allow considerable moisture to enter, which can cause efflorescence.

Masonry in contact with soil, such as in basement and retaining walls, may absorb ground water containing soluble salts. Through capillary action, salts present in the soil may rise several feet above the ground, producing an accumulation of salts in the masonry.

CONTROL OF EFFLORESCENCE

Since many factors influence the formation of efflorescence, it is difficult to predict if and when it will appear. However, to reduce the probability of efflorescence occurring in masonry construction, it is necessary to minimize the amount of soluble salts and moisture present in the masonry. Of the two, moisture is the more easily avoided.

Design

The reduction of moisture in concrete masonry will minimize the mechanisms that cause efflorescence. The designer must review each area of the design prior to construction to see if water can enter and where it will flow or accumulate if it does enter.

The selection of wall type—single-wythe, multi-wythe or cavity—should be considered from the standpoint of resistance to rain penetration and the exposures to which it may be subjected. Design details that will prevent the entrance of moisture into the masonry assembly are critical. Details that will direct water collection away from wall tops and horizontal surfaces should be considered. If architecturally feasible, wide overhanging roofs help protect walls from rainfall.

Parapets require special attention because of their exposure. Flashing should be installed in locations where water will tend to accumulate (i.e., parapets, spandrels, lintels, base of wall) within the masonry. The flashing should be installed to direct the water outward through weep holes.

Joints between masonry and door and window openings should be given careful attention during design as well as construction. Backer rods and sealants should be properly selected and installed in the same careful manner as other elements in the structure. TEK 19-2A *Design for Dry Single-Wythe Concrete Masonry Walls* and TEK 19-4A *Flashing Strategies for Concrete Masonry Walls* (refs. 4, 7) provide a more complete discussion on the proper use of flashings and details to minimize water entry.

Numerous surface treatments are available for the construction of weathertight concrete masonry walls. Properly applied, coatings can be relied on to give a satisfactory weathertight concrete masonry wall for up to 10 years in most geographic areas. Clear water-repellent surface treatments decrease efflorescence by repelling water from entering the masonry. However, the application of clear coatings to a masonry wall that has the tendency to effloresce, without reducing the mechanisms for the occurrence of that efflorescence, may lead to surface spalling of masonry units or deposits on the interior and/or exterior surface of the surface treatment.

The designer and owner may also want to consider the use of integral water repellents in the masonry. Integral water repellent admixtures have been shown to reduce the tendency to effloresce, since they reduce water migration throughout the wall. For more information on surface treatments and integral water repellents see TEK 19-1 *Water Repellents for Concrete Masonry Walls* (ref. 15).

Materials

In the selection of masonry materials, all component parts—masonry units, mortar and grout—should be considered for their soluble salt content.

At present there is no standard test for evaluating the efflorescence potential of concrete masonry units or mortar. However, in light of this absence, *Standard Test Methods of Sampling and Testing Brick and Structural Clay Tile*, ASTM C 67 (ref. 13) which does contain a test method to esitmate efflorescence potential, is occasionally specified to evaluate concrete masonry units for efflorescence potential.

All cement should meet applicable ASTM specifications. Lime should be hydrated lime and should meet the requirements of ASTM C 207 (ref. 14). Sand should meet the requirements of ASTM C 144 (ref. 1) and clean mixing water should be used.

If walls of hollow masonry units are to be insulated by filling the cores, the insulating material should be free of harmful salts.

Construction

Materials received at the construction project should be properly stored throughout the construction process. Units should be stored on pallets, or otherwise isolated from the ground, and be adequately covered to prevent water absorption.

Materials removed from stockpiles should be handled such that they remain protected from rain and soil. If colored units are involved, the distribution from the stockpile should be such that the color range of the units is known and units with acceptable color variations are uniformly dispersed throughout the field of the masonry.

During construction, the mixer, mortar box and mortar boards should be kept clean. During cold weather construction, this equipment should not be deiced with salt or antifreeze material. Tools should also be clean and free of rust, salts and other harmful material. For example, workers should not use a shovel for salt and then use it for sand without first thoroughly washing the shovel.

Inadequate hydration of cementitious materials caused by cold temperatures, premature drying or improper use of admixtures should be prevented.

At the end of the work day and after completing one segment of masonry, the top surface of the masonry should be protected to prevent water penetration. Uncovered masonry walls are vulnerable to large quantities of water entering the wall.

Close cooperation between the masonry contractor and designer is necessary to ensure good design and detailing are correctly carried through the construction. Workmanship greatly influences the weathertightness of concrete masonry walls. Concave or vee-shaped mortar joints should be used where the masonry will be subjected to rain or freeze-thaw exposure. Tooling of the joints should be delayed until the mortar is "thumbprint hard". This partial setting of the mortar provides resistance to the tooling action and forces the mortar tightly against the face shell of the unit to form a good weathertight seal. Joints that do not provide compression of the mortar during the tooling process such as raked, flush, and cut joints are not recommended for exterior applications. They not only do not provide the necessary compressing action against the unit, but by their very nature, leave a ledge for water to accumulate and slowly soak into the masonry.

Head joints are more vulnerable to leakage and poor workmanship as the force of gravity is not working to compress the mortar against the unit to provide a good seal. Head joints must be properly filled to the full thickness of the face shell and compacted by shoving the unit being placed against the previously laid unit. Then of course, the joint must be properly tooled.

The use of water to remove surface accumulations, including efflorescence, will cause additional water to enter the wall particularly if it is applied under high pressure. This water may promote further efflorescence.

REMOVAL OF EFFLORESCENCE

Before any effort to remove the efflorescence is undertaken, the reason for the efflorescence should be established. If it is "early age efflorescence," moist construction materials may be the cause. If "late age efflorescence" is observed, the possibility of water leakage should be investigated. If the efflorescence is near ground level, ground water may be the cause. In any case, the problem should be repaired prior to removing the efflorescence. Generally, if efflorescence is the main concern regarding masonry surface discoloration, the masonry walls should be allowed to cure and then the salts should be removed.

Compared to other stains, the removal of most types of efflorescence is relatively easy. As stated previously, most efflorescing salts are water soluble and many will disappear with normal weathering unless there is some external source of salts.

In general, most efflorescence can be removed by dry-brushing followed by flushing with clean water. If brushing is not satisfactory, it may be necessary to use a very light (brush) sandblasting to remove the deposits. Brush sandblasting is sandblasting which is light enough that coarse aggregate is not exposed by the sand blasting (ref. 8). Sand blasting needs to be done with care, as it can alter the appearance of masonry by roughening the surface or exposing aggregate. There also are a variety of commercial cleaners available which may be effective for efflorescence removal. Consult manufacturer's information for applicability.

As a last resort, a dilute solution of muriatic acid (5 to 10 percent) is sometimes used to clean the wall. For integrally colored masonry, a more dilute solution (2 percent) may be necessary to prevent surface etching that may alter colors and textures. Before an acid treatment is used on any masonry wall, the solution should be tested on a small, inconspicuous portion to be sure there is no adverse effect.

Before applying an acid solution, always wet the wall surface with clean water to prevent the acid from being absorbed deeply into the wall where damage may occur. Application should be to small areas of not more than 4 ft^2 (0.37 m^2) at a time, with a delay of about 5 minutes before scouring the salt deposit with a stiff bristle brush. Use a special acid cleaning brush. Do not use a wire brush as the filings of wire left behind could result in further staining as the steel corrodes. After this treatment, the surface should be immediately and thoroughly flushed with clean water to remove all acid. If the surface is to be painted, it should be thoroughly flushed with water and allowed to weather for at least one month.

Since an acid treatment may slightly change the appearance, the entire wall should be treated to avoid uneven discoloration or mottled effects. Windows, doors, or surrounding materials may need to be protected during application.

Calcium carbonate efflorescence is extremely difficult to remove. It appears usually as a flat white deposit and in the worst cases forms a hard white crust. Any effective methods of removal can alter the texture of the block to such an extent that it is necessary to treat the entire wall area and not merely the affected regions. One method of removal reported to be effective is the use of high pressure water jet, sometimes augmented with the addition of fine sand to the water.

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TEK 19-1
Water Penetration Resistance (2006)

WATER REPELLENTS FOR CONCRETE MASONRY WALLS

Keywords: coatings, paints and painting, plaster, sealants, waterproofing, water repellents

INTRODUCTION

Water repellents are used on exterior walls to provide resistance to wind-driven rain. In addition, water repellents can also reduce the potential for efflorescence and staining from environmental pollutants, and enhance the color or texture of a wall.

When applied in accordance with manufacturer's recommendations, water repellents effectively control water penetration. Water repellents are generally recommended for use on single wythe concrete masonry walls exposed to the weather. The choice of water repellent will depend on the surface to be protected, the exposure conditions, and on aesthetics. A wide variety of water repellents is available, offering many choices of color, surface texture, glossiness, and application procedures.

WATER RESISTANCE

Water penetration resistance of concrete masonry walls is dependent on wall design, design for differential movement, workmanship, wall maintenance, and the application of water repellents. This TEK focuses on water repellent products for above grade walls. The other factors are discussed in TEKs 10-2B, 19-4A and 19-5A (refs 3, 5, and 4).

The effectiveness of water repellents can be evaluated in several ways. In the laboratory, *Standard Test Method for Water Penetration and Leakage Through Masonry*, ASTM E 514 (ref. 9), is currently the only standard test method for water penetration. The test simulates 5 1/2 in. (140 mm) of rain per hour with a 62.5 mph (101 km/h) wind for a duration of 4 hours. This test is often used to evaluate water penetration before and after application of a water repellent, or to judge the relative performance of several water repellent systems.

TYPES OF WATER REPELLENTS

There are two general types of water repellents: surface treatment repellents and integral water repellents. Surface treatment repellents are applied to the weather-exposed side of the wall after the wall is constructed. In addition to water repellency, surface treatment repellents also improve the stain resistance of the wall, by preventing dirt and soot from penetrating the surface, causing deep stains.

When used on new construction, choose water repellents that are able to resist the alkalinity of the fresh mortar. As an alternative, an alkali-resistant fill coat can be applied to the wall first, or the wall can be allowed to weather for about six months until the alkalinity is reduced.

In general, surface treatment repellents should allow for vapor transmission to ensure that interior humidity within the wall and structure can escape. Treatments which are impermeable to water vapor tend to fail by blistering and peeling when moisture builds up behind the exterior surface.

When choosing a surface treatment repellent, manufacturer's guidelines should be consulted regarding appropriate substrates and applications for a particular product.

Regardless of the type of surface treatment chosen, it should be applied to a sample panel or on an inconspicuous part of the building to determine the appearance, application method, application rate, and compatibility with the masonry surface. Surface treatment repellents will require reapplication after a period of years to ensure continuous water repellency.

Integral water repellents are added to the masonry materials before the wall is constructed. The water repellent admixture is incorporated into the concrete mix at the block plant. This way, each block has water repellent throughout the concrete in the unit. For mortar, the water repellent is added to the mix on the jobsite. It is critical when using integral water repellents that the repellent is incorporated into both the block and the mortar to ensure proper performance of the wall.

The following sections describe in more detail the characteristics of various generic surface treatment repellents and integral water repellents.

SURFACE TREATMENT REPELLENTS

Cementitious coatings: Coatings such as stucco or surface bonding mortar can be used to increase the water resistance of a wall, as well as to significantly change the texture of the finished wall surface. Consideration should be given to differential movement which may transmit stress into the coating. Further information on stucco is found in TEK 9-3A (ref. 8).

Paints: Paints are colored opaque coatings, used when color uniformity of the wall is important for aesthetic reasons. Paints are a mixture of pigment, which hides the surface, and resin, which binds the pigment together. The proportion of pigment to resin, and the type of resin will affect the fluidity, gloss, and durability of the paint.

The pigment volume concentration (PVC) compares the amount of pigment in a paint to the amount of binder. As the PVC increases, the paint has more pigment and less binder. High PVC coatings are used where limited penetration is desired, such as for fill coats on porous materials. High PVC paints generally brush on easier, have greater hiding power, and usually cost less than low PVC paints. Low PVC paints are generally more flexible, durable, washable, and are glossier.

Fill Coats: Fill coats, also called primer-sealers or fillers, are sometimes used to smooth out surface irregularities or fill small voids before application of a finish coat. Common fill coats include latex coatings and portland cement. In addition, acrylic latex or polyvinyl acetate is sometimes combined with portland cement for use as a fill coat. Fill coats should be scrubbed vigorously into the masonry surface using a relatively short stiff fiber brush.

Cement-Based Paints: Cement-based paints contain portland cement as the binder, which creates a strong bond to the masonry and is not subject to deterioration from alkalis. Cement-based paints effectively fill small voids so that large amounts of water are repelled. Durability is excellent.

Cement-based paints are sold either premixed, or in dry form and mixed with water just before use. They should be applied to a damp surface using a stiff brush, and kept damp for 48 to 72 hours, until the cement cures. If the cement-based paint is modified with latex, however, wet curing is not necessary. White and light colors tend to be the most satisfactory.

Latex Paints: Latex paints are water-based, with any one of several binder types. They are inherently resistant to alkalis, have good hiding characteristics, and are durable and breathable, making them a good choice for concrete masonry walls. Butadiene-styrene paints and polyvinyl acetate emulsion paint are both categorized as latex paints. Latex paints can be applied to either damp or dry surfaces, and dry quickly, usually within 1 to 1 1/2 hours. They are generally inexpensive and easy to apply by brush, roller, or spray.

Alkyd Paints: Alkyd paints are durable, flexible, have good gloss retention, are low in cost, but have low alkali resistance. They should be sprayed on, since they tend to be difficult to brush apply. They dry quickly once applied.

Clear Surface Treatment Repellents: Clear treatments are used to add water resistance to a wall without altering the appearance. These treatments are classified by the resin type, such as silicone or acrylic.

Clear treatments can be classified as either films or penetrant repellents. Penetrant repellents are absorbed into the face of the masonry, lining the pores. They adhere by forming a chemical bond with the masonry. Penetrant repellents do not bridge cracks or voids, so these should be repaired prior to applying the treatment. Silanes and siloxanes are penetrant repellents. Films, such as acrylics, form a continuous surface over the masonry, bridging very small cracks and voids. Because of this, films can also reduce the vapor transmission of a concrete masonry wall. Films tend to add a glossier finish to the wall surface, and may intensify the substrate color.

Silicones: Silicones can be further subdivided into silicone resins, silanes, and siloxanes. These treatments change the contact angle between the water and the pores in the face of the masonry, so that the masonry repels water rather than absorbing it. Silicones have been found to reduce the occurrence of efflorescence on concrete masonry walls.

Silicone resins: These are the most widely used silicone-based water repellents for masonry. They can penetrate the surface of masonry very easily, providing excellent water repellency. Silicone resins should be applied to air dry surfaces, and are usually fully dry after 4 to 5 hours.

Silanes: Like silicone resins, silanes have good penetration characteristics. Although volatility of silane has been a concern, the absorption of silane by masonry generally occurs at a much faster rate than evaporation of the silane. Silanes, unlike silicone resins, can be applied to slightly damp surfaces.

Siloxanes: Siloxanes have the benefits of silanes, i.e., good penetration and ability for application on damp surfaces. Siloxanes are effective on a wider variety of surfaces than silanes, and dry relatively quickly. Costs are comparable to silanes, and are slightly higher than silicone resins.

Acrylics: Acrylics form an elastic film over the surface of masonry to provide an effective barrier to water. Acrylics dry quickly and have excellent chalk resistance. Acrylics should be applied to air-dry masonry surfaces. Costs tend to comparable to silicone resins.

OTHER TREATMENTS

Epoxy, Rubber, and Oil-Based Paints: These paints form impervious moisture barriers on concrete masonry surfaces. This makes for an excellent water barrier, but does not allow the wall to breathe. As such, these paints are generally not considered water repellents. These treatments are better limited to interior walls, since they can blister and peel when used on exterior walls.

Oil-based paints adhere well to masonry, but are not particularly resistant to alkalis, abrasion, or chemicals. Rubber and epoxy paints offer high resistance to chemicals and corrosive gases, and are generally used in industrial applications.

APPLICATION OF SURFACE TREATMENT REPELLENTS

This section contains some general guidelines for application of surface treatments. In all cases, refer to manufacturers' literature for final recommendations and procedures. Surface treatments should typically be applied to clean, dry walls. Wall surfaces should be cleaned in accordance with manufacturer's instructions to ensure good adhesion and penetration. The wall should be allowed to dry for 3 to 5 days between cleaning or rain and application of the repellent. All cracks and large voids should be repaired prior to applying the repellent. If caulk is used in the repair, the caulk should be compatible with the surface treatment repellent and fully cured before treatment application.

Weather can have a significant effect on the application and curing of water repellents. It is usually recommended that the repellent be applied when temperatures are expected to remain above 40°F (4 °C) during the two to four days after application. There should be little or no wind during spray-on applications, to avoid an uneven coating and drift of the treatment onto other materials. Adjacent landscaping should be protected during application, and, depending on the surface treatment, it may also be necessary to protect other building materials, such as aluminum or glass.

Most manufacturers recommend applying clear surface treatments using a saturating flood coat, with a 6 to 8 in. (152 to 203 mm) rundown below the contact point of the spray. It is sometimes recommended that a second coat be applied when the first is still wet. Coverage rates vary from 75 to 200 ft^2/gallon (1841 to 4908 m^2/m^3) depending on the surface treatment repellent used and the type and condition of the masonry.

When applying a water repellent over a previously treated wall, ensure that the new treatment is compatible with the old. With some surface treatments, masonry should be uncoated for proper adhesion. In these cases, the old treatment can be allowed to weather off, or, if time does not permit this, a pressurized wash followed by high pressure water rinse can remove previous surface treatments from masonry.

The durability of a coating is a function of the type of coating, the application procedure, the rate of application, the surface preparation, and the exposure conditions. For this reason, it is difficult to predict how the various surface treatment repellents will perform under field conditions.

INTEGRAL WATER REPELLENTS

Integral water repellents are usually polymeric products incorporated into the masonry products prior to construction. Because integral water repellents are evenly distributed throughout the wall, they do not change the finished appearance. In addition, integral water repellents are effective at reducing efflorescence, since water migration throughout the block is reduced.

As stated earlier, it is essential that an integral water repellent admixture be incorporated into the mortar at the jobsite, as well as into the block and any other masonry wall components, such as precast lintels. The same brand of water repellent admixture should be used in the mortar as was used in the block, to ensure compatibility and bond.

Questions often arise regarding the effect of integral water repellents on mortar bond strength, due to the decreased water absorption. Research has shown that bond strength is primarily influenced by the mechanical interlock of mortar to the small voids in the block.

When walls containing integral water repellents are grouted, the grout produces a hydrostatic pressure which forces water into the surrounding masonry unit, allowing proper curing of the grout.

Generally, the use of other admixtures in conjunction with integral water repellents is not recommended. Some other admixtures, especially accelerators, have been shown to reduce the effectiveness of integral water repellents.

Some integral water repellents are soluble when immersed in water for long periods of time. Conditions which allow standing water on any part of the wall should be avoided. For this reason, mortar joints should be tooled, rather than raked. In addition, walls incorporating integral water repellents should not be cleaned with a high-pressure water wash.

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DEFINITIONS

Acrylic—A thermoplastic synthetic organic polymer made by the polymerization of acrylic derivatives such as acrylic acid, methacrylic acid, ethyl acrylate, and methyl acrylate; used for adhesives, protective coatings, and finishes.

Alkyd resin—A class of adhesive resins made from unsaturated acids and glycerol.

Film repellent—A protective treatment that fills masonry pores, forming a continuous film on the surface.

Integral water repellent—An admixture incorporated during the manufacture of concrete masonry units and added to the mortar mix to improve the water repellency characteristics.

Latex—Milky colloid in which natural or synthetic rubber or plastic is suspended in water. An elastomer product made from latex.

Latex paint—A paint consisting of a water suspension or emulsion of latex combined with pigments and additives such as binders and suspending agents.

Penetrant repellent—A protective treatment that lines masonry pores; no film is formed on the surface.

Polyvinyl acetate—A thermoplastic polymer; insoluble in water, gasoline, oils, and fats; soluble in ketones, alcohols, benzene, esters, and chlorinated hydrocarbons; used in adhesives, films, lacquers, inks, latex paints, and paper sizes.

Silane—Generally refers to alkyltrialkoxysilanes. A monomeric organosilicon compound with one unhydrolyzable siliconcarbon bond, which forms a chemical bond with siliceous minerals providing water repellent protection. Silanes are usually dissolved in organic solvents, but some are dispersed in water.

Silicone—A fluid, resin, or elastomer; can be grease, a rubber, or a foamable powder; the group name for heat stable, water repellent, semiorganic polymers of organic radicals attached to silicones, for example, dimethyl silicone; used in adhesives, cosmetics, and elastomers.

Siloxane—Generally refers to alkylalkoxysiloxanes that are oligomerous (i.e., siloxane of low molecular weight with the polymer consisting of two, three, or four monomers). As with other silicones, application is accompanied by chemical bonding to the substrate if silicate materials are present.

Styrene-butadiene—The most common type of synthetic rubber, made by the copolymerization of styrene and butadiene monomers; used in tires, footwear, adhesives, and sealants. Also known as SBR.

Surface treatment repellent—Any water repellent material applied to the surface of any substrate.

Water repellent—Property of a surface that resists wetting (by matter in either liquid or vapor state) but permits passage of water when hydrostatic pressure occurs.

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FLASHING STRATEGIES FOR CONCRETE MASONRY WALLS

TEK 19-4A
Water Penetration Resistance (2008)

Keywords: flashing, flashing materials, maintenance, moisture, vents, wall drainage, water resistance, weep holes

INTRODUCTION

The primary role of flashing is to intercept the flow of moisture through masonry and direct it to the exterior of the structure. Due to the abundant sources of moisture and the potentially detrimental effects it can have, the choice of flashing material, and the design and construction of flashing details, can often be as key to the performance of a masonry structure as that of the structural system.

The type of flashing material to be used is governed by both environmental and design/build considerations. Environmental considerations include such factors as the physical state of moisture present (liquid, solid, or vapor), air movement, and temperature extremes as well as temperature differentials. Design/build considerations include the selection of the proper type of flashing material, location of the flashing, structural, and installation details. Drawings for flashing details, often the only method of communicating the necessary information between the designer and contractor, should be comprehensive and show sufficient detail for the proper interpretation and installation of flashing systems. TEK 19-5A *Flashing Details for Concrete Masonry Walls* (ref. 3) includes such details.

Although flashing is the primary focus of this TEK, it should be understood that the role of vapor retarders, air barriers, and insulation are also important elements to consider for any wall design as the performance of the entire system can be dependent on the design of its individual components.

EFFECT OF MOISTURE ON MASONRY

The damage caused to a masonry structure (or its contents) due to the infiltration of moisture can take many forms, depending on the source and the physical state of the water. For example, in the liquid state, water penetrating to the interior of a building may cause considerable damage to its contents. In some extreme cases, water trapped within the masonry may freeze, inducing spalling and cracking of the masonry units or mortar. Alternatively, water vapor can lead to condensation inside the cores and on the surfaces of masonry if the dew point temperature is reached. During cold weather, below 28 ^{o}F (-2 ^{o}C), water vapor can accumulate on a cold surface and form frost or increase the quantity of ice within the masonry.

Although it is commonly thought that moisture problems stem only from the external environment, this is not always the case. For example, in some instances it is possible for the humidity of interior air to cause water damage to the exterior of a structure. This damage may appear in the form of water stains, ravelled mortar joints, spalled surfaces, or efflorescence.

DESIGN CONSIDERATIONS

Water Movement

In the design of any structure, the presence and movement of water in any of its three forms needs to be considered. Significant forces that influence water movement include wind pressure, gravity, and moisture absorption by the material. Dynamic wind pressure on the surface of an exposed wall can drive exterior moisture (in the form of rain or irrigation water) into the masonry. Gravity, which is always present, draws the free water vertically downward, while the absorptive characteristics of the masonry can cause moisture migration in any direction by capillary action.

It should also be recognized that these forces do not act independently of one another. For example, wind-driven rain may enter masonry through cracks at the interface between mortar and units and migrate downward through the wall due to the force of gravity, or it may be transferred horizontally through the wall either by pressure or by flowing across the webs of the units or mortar bridges. Wind-driven rain can also be absorbed by masonry units and carried from the exterior surface to the interior surface by capillary action. Additionally, ground water may be drawn upward by the wicking action of units placed on porous foundations or by contact with moist soil.

Designers should never assume that any material is capable of rendering a wall totally impervious to water penetration. Surface treatments, designed to reduce the quantity of water entering a masonry structure, are helpful in this regard but should not be considered as a sole means of protection.

Available as clear and opaque compounds, the effectiveness of surface treatments depends on their composition and compatibility with the masonry. They also do not reduce the movement by capillary action (wicking) of any water that does penetrate the masonry face through cracks or defects in the mortar/masonry.

The use of integral water repellent admixtures in concrete masonry units and mortars can also reduce the amount of water entering the masonry. In addition, they inhibit water penetrating the masonry face from wicking to the back face of the wall.

Proper selection and application of surface treatments and integral water repellents can greatly enhance the water resistant properties of masonry, but they should not be considered as substitutes for flashing. See TEKs 19-1 and 19-2A (refs. 8 and 2) for more information on water repellents for concrete masonry.

Flashing Location

The proper design of masonry for resistance to water penetration includes consideration of the various types of wall construction such as single wythe, cavity, veneer, etc. During the design phase it should be understood that all exterior masonry walls may be subjected to some degree of water penetration and/or water vapor movement during its design life. Flashing is recommended for all locations where moisture may potentially penetrate into a wall and where the free drainage of water is blocked. Some of these critical locations include the top of walls and parapets, at all horizontal obstructions such as over openings, beneath sills, above shelf angles, at the base of walls, and in walls at ground level to serve as a moisture retarder to reduce the amount of water wicked up into the masonry above grade.

When selecting the flashing material for a particular application, the service conditions, projected life of the structure, and past performance characteristics of the flashing materials should be reviewed. Flashing should be designed to perform satisfactorily for the design life of the building since repair or replacement can be very labor intensive and expensive.

FLASHING MATERIALS

A wide variety of flashing materials are available. The selection of the type of flashing material to use can be influenced by several factors including cost, durability, compatibility with other materials, ease of installation, aesthetic value, and performance. Table 1 summarizes some of the attributes for various flashing materials. The advantages and disadvantages of each must be weighed for each individual project to provide the most cost-effective and desirable choice.

Prefabricated flashing boots may be available for inside and outside corners and end dams. These boots eliminate the need for cutting, folding, or tucking the flashing materials at these locations. However, due to construction tolerances, some of these prefabricated items, particularly those of rigid materials, may be difficult to fit into their intended location.

Sheet Metals

Stainless steel is technically any of a large and complex group of corrosion resistant iron chromium alloys possessing excellent weather and chemical resisting properties. Preformed sections must be properly sized so that on site modification is minimized. Stainless steel flashing with a conventional annealed finish should comply with *Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip*, ASTM A 167 (ref. 6). Generally, Type 304 stainless steel with a minimum thickness of 0.010 in. (0.25 mm) is satisfactory. Lap sections require solder conforming

Table 1 - Flashing Material Properties (refs. 1, 7)

Material	Advantages	Disadvantages
Sheet Metals		
Stainless Steel	Very durable, non-staining	Difficult to solder and form
Cold-rolled copper	Flexible, durable, easy to form and join	Damaged by excessive flexing, can stain surfaces
Galvanized steel	Easy to paint and durable	Difficult to solder, corrodes early in acidic and salty air
Composites		
Lead-coated copper	Flexible, durable, non-staining	Difficult to solder, damaged by excessive flexing, metal drip edge suggested
Copper laminates	Easy to form and join	Degrades in UV light, more easily torn than metal
Plastics and Rubber Compounds		
EPDM	Flexible, easy to form and join, non-staining	Aesthetics if not used with a metal drip edge, full support recommended
Rubberized asphalt	Fully adhered, separate lap adhesive not needed, self-healing, flexible. easy to form and join	Full support requied, degrades in UV light, metal drip edge required
PVC	Easy to form and join, non-staining, low cost	Easily damaged, full support required, metal drip edge required, questionable durability

to *Standard Specification for Solder Metal*, ASTM B 32 (60% tin and 40% lead) (ref. 5). Stainless steel drip edges used in combination with other flashing materials offer an economical compromise with a durable drip edge.

Copper is a nonferrous metal possessing good ductility and malleability characteristics. Like stainless steel, it also possesses excellent weather and chemical resistant properties. Preformed sections or sheet materials are easily modified to conform to site requirements. However, it should be cautioned that once weathered, copper flashings produce a green patina that may impart a green stain to adjacent masonry surfaces that some find objectionable.

Galvanized steel is less expensive than stainless steel but is subject to corrosive attack from salts and acids. The galvanized coating also may crack at bends, lowering the corrosion resistance. As with stainless steel, it is also difficult to form and to solder laps effectively.

Composites

Combinations of metals and plastics are supplied by some dealers. The composition and application of these combined materials should be determined before use. Composites utilizing copper are the most popular since they combine the durability and malleability of copper with the nonstaining characteristics of a protective coating. Composites containing aluminum should be avoided.

Plastics and Rubber Compounds

Plastics are categorized as polymeric materials of large molecular weight, usually polyvinyl chloride (PVC) or polyethylene. Manufacturers of plastic flashings should be consulted for documentation establishing the longevity of the plastic in a caustic environment (pH = 12.5 to 13.5), the composition of the plastic, ease of working at temperatures ranging from 20 to 100 °F (-7 to 38 °C), and ability to withstand exposure to ultraviolet light.

Ethylene Propylene Diene Monomer (EPDM) is a synthetic rubber that is used as a single ply roofing membrane as well as flashing. It has better low temperature performance than PVC and will not embrittle. It offers ultraviolet light and ozone resistance and can be left exposed.

Self-adhering, rubberized asphalt membranes consist of a composite of flexible plastic film for puncture and tear resistance combined with a rubberized asphalt adhesive layer. This material adheres to itself, requiring less effort to seal laps or corners which speeds installation. It also self-adheres to the substrate which prevents water from migrating under the flashing and is self-healing in the event of punctures. However, it should not be applied to damp, dirty, or dusty surfaces and typically has a lower installation temperature limit of 25 °F (-4 °C). Because it degrades in the presence of extended UV exposure, it should not be left exposed and requires a metal drip edge.

CONSTRUCTION PRACTICES

To perform, flashing must be designed and installed properly or it may aggravate rather than reduce water problems. Flashing should be longitudinally continuous or terminated with end dams. Longitudinally continuous requires that joints be overlapped sufficiently, 4 in. (102 mm) minimum, to prevent moisture from entering between the joints and they must be bonded (joined) together with adhesive if they are not self adhering to prevent water movement through the lap area. With metal flashings a ¼ in. (6.4 mm) gap joined and sealed with a pliable membrane helps in accommodating expansion (ref. 3).

Flashings should be secured at the top by embedment into the masonry, a reglet, or should be adhesively attached so that water cannot infiltrate or move behind the attachment. For multi-wythe construction, the flashing should project downward along the outer surface of the inner wythe and then project outward at the masonry joint, shelf angle, or lintel where it is to discharge the water. Every effort should be made to slope the flashing towards the exterior. Effectively placed mortar or sealant material can help promote this drainage. The flashing should continue beyond the exterior face of the masonry a minimum of ¼ in. (6.4 mm) and terminate with a sloped drip edge.

An additional design consideration for flashings includes ensuring that all materials are compatible. For example, contact between dissimilar metals can result in the corrosion of one or both of the metals. Additionally, the coefficients of thermal expansion for the flashing and masonry materials differ. All flashing details should be designed to accommodate the resulting differential movement.

Other recommended practices involve the use of tooled concave mortar joints to reduce water penetration through the mortar joints. Masons should be careful to ensure that mortar dropped onto the flashing is minimized. This can be accomplished by beveling the mortar on the face shells adjacent to the cavities in cavity wall construction. In addition, cavity drainage mats, gravel beds, screens, or trapezoidal drainage material (filter paper) can be used to prevent mortar droppings from collecting on the flashing, which can form dams and block weep holes. Mortar collection devices at regular intervals or filling the cells with loose fill insulation a few courses at a time as the wall is laid-up, can be effective in dispersing minor mortar droppings enough to prevent clogging.

Weep holes, the inseparable companion to flashings, should provide free movement of water out of the concrete masonry cores, collar joints, or cavities. Any construction practice that allows forming the weep holes without inhibiting water flow may be used. Cotton sash cords and partially open head joints are the most common types of weep holes. Cotton sash cords should be removed prior to putting the wall into service to provide maximum unobstructed drainage. If necessary, insects can be thwarted by inserting stainless steel wool into the openings or using plastic or metal vents.

Vents

Weep holes often serve a dual function, first for water drainage and second as vents. Vents are desirable in some masonry wall systems to help reduce the moisture content of the masonry during drying periods. Air circulation through the cores and cavities within the masonry promotes equalization of moisture content throughout the masonry. Vents are considered desirable where air is confined within masonry, such as in parapets or areas of high humidity such as natatoriums.

MAINTENANCE

Maintenance programs should involve preserving the "as-built" design documents, records pertaining to inspections during the life of the structure, and continuing appraisal of the performance of the structure in addition to conventional repair and upkeep. Documentation of inspections, if efflorescence and water stains are observed, and logs of reported water penetration and their identified location, assist in determining proper corrective actions. Pictures with imprinted dates are suggested.

Knowledge of the wall design and construction can influence repair decisions. If flashing and weep holes were omitted during construction, it may prove effective to simply drill weep holes and vents to promote drainage and drying. Weep holes so drilled should be either at the intersection of the bed and head joints or into the cores at the bottom of the wall. Vents should be installed at the top of the wall or directly below bond beams. See TEK 8-1A *Maintenance of Concrete Masonry Walls* (ref. 4) for more detailed information on maintenance of concrete masonry walls.

When considering maintenance options, it is important to ensure that a masonry wall's moisture control measures are kept intact. Thus, applying sealant beads, pargings, or coatings to a wall should be carefully weighed. Weep holes and vents should be maintained in an open condition to allow evacuation of moisture.

SUMMARY

Flashings are essential at foundations, bond beams, above and below openings, at shelf angles and at copings. Weep holes and vents reduce the moisture content of masonry walls. Proper selection of flashing materials, proper detailing, and proper installation will help ensure satisfactory performance.

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