PDCA Technical Paper Number 100

Responsibilities And Limitations Regarding Efflorescence In Masonry, Stucco, And Cementitious Substrates

INTRODUCTION

This technical paper explains efflorescence and makes recommendations to reduce or eliminate its appearance through specifications, design, and construction. The limitations of water-resistant coatings regarding efflorescence are also explained.

DESCRIPTION

Efflorescence is the manifestation of a process: water dissolves salts present within a substrate, this salt solution migrates to the substrate's surface, and a salt deposit remains after the water evaporates. Efflorescence can appear on the surface of coated or bare masonry, stucco, or cementitious substrates. In most situations, efflorescence alone, causes little damage.

This salt formation is usually white in appearance. Its greatest aggravation is that it usually appears within a short period after the building is constructed. The so called "New Building Bloom" appears when the contractor, architect and owner are most concerned about appearance. This form of efflorescence usually becomes lighter with time and less extensive when it has been caused by an internal source of salts. However, efflorescence is not only caused by internal salts and its appearance may occur months or even years after a building has been constructed. Extended periods of moisture may cause the salts to seed out beneath a coating's film and cause it to lose adhesion or cause latent damage to the paint film. In limited cases the actual substrate may become spalled or steel elements such as lintels or rebar, may oxidize causing cracking of joints or substrates.

For the process of efflorescence to occur, four things must be present - salts, moisture, a physical force, and an opening.

Salts are very common minerals occurring in earthen building materials. Quantities of water-soluble salts as small as a few tenths of one percent are sufficient to cause efflorescence. These small quantities of salts have been found in drinking water or other water supply sources used for mixing or manufacturing materials. Salts may also leach from soil and migrate into a building substrate. A dilute solution of muriatic

(Hydrochloric) acid used to clean dried mortar from masonry may cause chloride salts to form on the surface if it is not thoroughly rinsed.

Physical Forces, such as wind, can force water into a building substrate. The movement of wind over the surface of a building can create pressure differentials that cause water to move upward. Capillary action can cause water to move upward and laterally within a substrate. These physical forces, as well as others, can increase the absorption of water that leads to efflorescence.

Moisture Whenever water is present, the potential for efflorescence increases if latent salts exit in the substrate, and/or an external source of salt is present. Repeated cycles of water saturation and evaporation cause salts to migrate from the substrate and efflorescence occurs.

Considerable water is necessary to manufacture concrete masonry units and brick. For example, two and three quarters gallons of water are necessary to properly hydrate one sack (94 pounds) of Portland cement. Cleaning can add even more water to the substrate during the construction process.

Precipitation, both during the building process and afterwards, encourage efflorescence. Efflorescence most often appears on buildings after long periods of precipitation during cool weather. During such periods, walls become increasingly saturated from the outside to inside. A building's warm interior can encourage such saturation. Voids in the substrate can also become extremely saturated with water vapor. As the weather clears, the walls begin to dry. Drying, caused by evaporation, occurs from the outside in and from the top down. As this evaporation occurs, water travels down from the top of a wall until an obstruction is encountered, or least resistance is found. Evaporation also causes water vapor to form toward the inside of the wall and above the falling column of saturation. When water and water vapor warm, even more salt dissolves. Thus, both water and water vapor present in the wall can become highly saline due to chemical and physical forces.

During freeze-thaw cycles, ice may thaw from the side closest to the interior due to warming, and water will be absorbed deep into the substrate, trapped by the outer skin of ice. This may occur despite the presence of a water repellent, since the natural forces present are greater than the force to repel. Upon melting, water migrating back to the surface may be extremely saturated with salts, which are heavily deposited on the surface due to a very slow rate of evaporation.

Hydrostatic pressure may also be present under below-grade slabs and behind below-grade walls. If no vapor barrier is installed, ground water can move upward by the process of capillary action. This migration of water is also referred to as wicking. Ground water may carry salt crystals leached from the soil. These salt crystals, within the substrate, will then be released.

Condensation is a major factor in the formation of efflorescence. Increased thermal resistance of a wall will make the outside components colder. Moisture laden air, moving through the building envelope, is cooled and becomes more saturated. When it reaches total saturation at its dew point, water condenses out of the air. This condensation may occur inside the wall cavity, or on the exterior wall surface. Therefore, the apparent absence of moisture does not eliminate the chance of efflorescence.

Openings The upward movement of water created by wind-driven rain and pressure differentials intrude at improperly designed and/or installed sheet metal flashing. Uncaulked sheet metal coping and uncapped parapets are other sources of moisture intrusion.

Hairline cracks and other openings at mortar joints can be a large source of water entry into a building. Shelf angles of brick, mortared instead of caulked, may crack with load deflection, creating cracking and a point of water entry. Cracks created by settling, resonant vibrations created by air, automobile or train traffic, electrolysis and oxidation rebar mat cracking, and thermal cracking because of improperly placed or nonexistent control joints all create points of water entry.

Voids caused by shrinkage of concrete products, or growth as with clay products, allow water intrusion. Bug holes, because of under vibration of concrete, can be too large to be protected by water repellents. Thus, allowing water intrusion.

COMMENTS AND RECOMMENDATIONS

Although efflorescence is a natural phenomena, both proper design and construction methods can effectively reduce the likelihood of its appearance. The appearance of efflorescence on a surface is a latent defect created by a problem within the substrate and/or other forces acting on that substrate.

Design should be the first line of defense against water intrusion. Criteria should be established creating a building envelope by proper integration of design elements. Particular attention should be paid to adequate flashing, coping assemblies, vapor barriers and waterproofing membranes. Since water may penetrate a wall, the design should also integrate measures such as weepholes and in-wall flashing that diverts water back to the outside. The proper selection and gradation of aggregates can effectively reduce the rate of absorption by creating a less impervious substrate.

Current ASTM standards should be specified as reference standards. These standards effectively reduce or eliminate the amount of efflorescence by establishing standards for material quality and work. Trade standards that establish quality of work and material, and design recommendations, should also be specified by reference.

When coatings are required on surfaces where efflorescence has been treated, there remains the possibility that entrapped or hidden moisture may cause the efflorescence to reappear and cause paint failure. An investigation should be conducted by persons, or entities, administering the project. Causes should be determined and corrective action taken so as to prevent the recurrence of efflorescence to the greatest extent possible. Only after corrective action is completed should the painting contractor be directed to apply the coating. Investigation, testing, and continued maintenance by all parties are required to effectively reduce or eliminate this recurrence.

A dilute solution of acid used to clean dried mortar from masonry may cause chloride salts to form on the surface if it is not thoroughly rinsed. Acid etching is not a recommended form of surface preparation where efflorescence is present for the following reasons: (1) This adds more water to the problem. (2) Thorough rinsing of the acid continues to add more water to the situation. (3) More drying time, which is subject to temperature and humidity conditions, is needed before finishing can begin.

GLOSSARY OF TERMS

ABSORB: To take up a substance into or throughout by physical or chemical means.

APPARENT: Real and evident, obvious.

CRYSTALLIZE: To come out of solution in the form of a crystal, the solid state of a substance or mixture.

ELECTROLYSIS: The passing of an electric current through an electrolyte (a fused salt or liquid solution) to produce chemical changes in it.

HYDROSTATIC PRESSURE: The pressure at any point of a liquid at rest. The force of a liquid generated in the attempt to reach an equilibrium.

LATENT: Hidden; dormant; present but unseen until some change occurs.

SUBSTRATE: A layer underneath; esp. constituting a support layer for that which is above it.

SURFACE: The two-dimensional boundary of a material body, which has breadth and width but no depth.

WATER PERMEABILITY: The ability of a coating to allow moisture to pass through it from one side where it is high to the other side where it is low or nonexistent.

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