THE EFFLORESCENCE REPORT

February 2009 by Harold B. Newman, CrE

When efflorescence shows up on a paving installation, the first inclination is to blame the unit paver for the problem because efflorescence is showing up on the product. This report addresses this issue and the occurrence of efflorescence on Pine Hall Brick clay pavers.

Harold B. Newman is Vice President of Technical Services for Pine Hall Brick Co. in Winston-Salem, NC. Mr. Newman holds an engineering degree in ceramics from Clemson University and has over 40 years experience in the brick industry doing research and technical services. He serves as the current Chairman of the **National Brick Research Center (NBRC)** as well as chairing the **ASTM C15** clay paver task group that is charged with oversight of ASTM C902 & C1272 standards. His 10 year research study on efflorescence earned him industry recognition as "the expert" on the topic. He regularly speaks to trade audiences on technical issues including segmental paving, veneer wall construction, ASTM standards, and brick manufacturing methods. In addition, he conducts an annual "brick school" for industry professionals and he has authored numerous articles for trade publications.

RAW MATERIALS

The clay shale utilized by Pine Hall Brick in the manufacturer of our products does not chemically contain enough material to produce efflorescence when fired to 2000 F. Fired paver products contain very low concentrations of sulfur, calcium, sodium, potassium, and magnesium. If present before firing, most of these ingredients either decompose or are incorporated in the glassy matrix during the vitrification process. Any remaining un-reacted materials are in concentrations well below the thresholds to generate efflorescence based on experience in the field and in laboratory research. As a result,

Pine Hall Brick pavers are not the source for any efflorescence showing up on paver surfaces in an installation or in an unused package.

SOURCES OF EFFLORESCENCE SCIENTIFICALLY IDENTIFIED

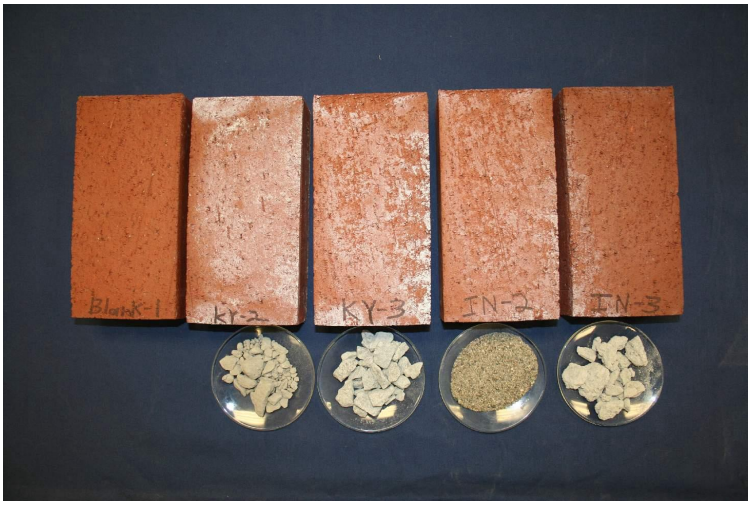
There are a number of potential sources of soluble materials that could contribute to appearance of efflorescence on clay paving products in service even though the product itself is free of the soluble salts. Forensic work has shown the following materials have contributed to efflorescence:

1. De-icing materials
2. Base Materials
3. Bedding Materials
4. Joint Sands
5. Joint Sand Mixtures with Portland Cement
6. Concrete Base and Curbing
7. Mortar
8. Collateral Materials Including Soil Sterilizers
9. Fertilizers
10. Ground Water
11. Water Sprinklers
12. Cleaners

A series of studies on the potential of efflorescence sources from various base and bedding materials collected across the USA has been done at the **National Brick Research Center** (an accredited independent testing laboratory) at Clemson University in collaboration with the Brick Industry of America.

In these ongoing studies, various materials were tested for soluble salts measuring cation and anion concentrations using an ion chromatograph. A modified efflorescence test was run whereby clay pavers, which did not show any evidence of efflorescence in the normal ASTM C-67 test , were set on beds of the various aggregate samples set up in individual plastic dish containers. A fixed portion of distilled water was placed in the container and a plastic lid was cut to expose only the surface of the clay paver to evaporation. The containers were placed in a controlled atmosphere with a fan blowing across the surface of the dish. Following 7 days of exposure, the samples were removed and dried in an oven and evaluated for the evidence of efflorescence. Several dishes were also included which did not contain any setting materials. See pictures right and below. ***(Note: clay pavers used in this study were the Pine Hall Brick 4 x 8 Pathway units)***

Container Set Up-Efflorescence Test



Aggregate Efflorescence Test Results (standard sample far left)

Controlled Environment

The National Brick Research Center concluded that there is a definite correlation between soluble anion & cation concentrations and the potential for efflorescence. A total of 6 out of 13 aggregate samples generated efflorescence on the pavers with *none of the standard samples (without bedding material) showing any evidence of efflorescence*. Early indications (from progress reports) show that there is a concentration threshold of 100 parts per million needed for efflorescence to occur and that source aggregates producing efflorescence had sulfate concentrations in excess of 100 ppm.

This testing validates the facts that Pine Hall Brick pavers do not efflorescence on their own and that efflorescence will occur on a pavement surface by transferring soluble salts from contaminated base and bedding materials through the brick.

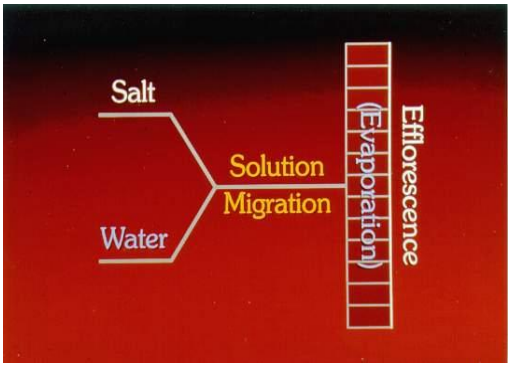
MATERIAL TRANSFER THROUGH MIGRATION

It is a known fact that water will migrate through a porous substance by capillary action. This is why a paper towel will pick up water spilled on the floor. This is the mechanism that carries a salty solution through a brick body to the surface of evaporation. If a paver is set on end in a pan of water, the water will wick or climb up the paver through the capillary structure in the paver. If pavers are stacked on top of each other, any moisture or salty solution will continue to migrate up the stack as long as there is a source of water and a moisture gradient present. The drying action works in the same manner, any moisture in a porous substance will migrate through the capillary structure to the surface of evaporation. This explains why efflorescence shows on the pavement surface even though the source of efflorescence is commonly in bedding materials and why an unused package of pavers may show evidence of efflorescence even in the interior of the stack.

A good example of this would be when pavers are stacked on an aggregate base yard that is contaminated with soluble salts, either from it's virgin location, in transit to the point of deposition, or from de-icing salts. When the surface of the yard gets wet, the salts are dissolved in water and migrate into the stack of pavers. When the pavers dry out, the transported salt shows up on the surface as efflorescence. See picture.

The transfer of soluble salts can even occur with acid rain causing efflorescence. This is especially true if any industrial plants that fire coal are in the vicinity of either point of manufacturer, distributor storage yard or job site. In these instances, moisture laden air that contain the soluble materials can be absorbed by porous clay products and in turn generate efflorescence. Although rare, acidic rain can enter the clay products and cause a reaction within the product that will create soluble materials.

EFFLORESCENCE- THE PROCESS & TESTING



Efflorescence requires three conditions to exist:

1. The presence of soluble salts
2. The presence of water
3. A path of migration of soluble laden solutions to the surface of evaporation

Little can be done to control the deposition of moisture in paving applications except to provide proper drainage. The main controlling factor to minimize the occurrence of efflorescence is to minimize the presence of soluble salts.

The efflorescence potential of fired clay products can be evaluated using the ASTM C-67 procedures. The clay product collected from the kiln prior to being subjected to the atmosphere is partially submerged in distilled water for as period of 7 days. Following the 7-day period the products are dried in an oven and

evaluated for the presence of efflorescence. The tested products are compared to products that have not been subjected to the leaching test. When viewed from a distance of 10 feet, if there is no difference in the appearance of the test samples and the standard sample the rating is "not effloresced". If the samples show a perceptible difference due to efflorescence the rating is "effloresced".

Numerous efflorescence tests have been run at independent laboratories on Pine Hall Brick clay pavers for over 20 years and in all instances the rating has been " not effloresced". These additional results reinforce that Pine Hall Brick pavers do not effloresce on their own.

BEST PRACTICES TO AVOID EFFLORESCENCE

- **Avoid soluble salt carrying aggregates like limestone. Limestone aggregates and manufactured sand should not be used if efflorescence is a concern.**
- **Educate the customer in advance that certain situations or products will cause efflorescence to appear on the paver but it will go away as the salts dissipate. In the case of soluble salt carrying aggregates, the salts may never fully dissipate.**
- **Recommend magnesium chloride deicer products(MagChloride). This type of deicer works better in colder temperatures as well as minimizes efflorescence later.**
- **Use well graded bedding sands that permeate water. "Screenings" tend to hold water that mixes with soluble salts and eventually produces efflorescence.**
- **Install weep holes in concrete bases for good drainage.**

EFFLORESCENCE REMOVAL

- **Vacuum the salt powder if possible. Then, flush the surface with water downgrade to wash the salt away from the pavement surface. This process will need to be repeated, after drying, as some salts will get reabsorbed into the paving system.**
- **If the salt does not disappear in contact with water, the salt stain will need to be removed by a special cleaner *like ProSoCo's Light Duty Concrete Cleaner.***

SEALER OPTION

Laboratory testing shows that some sealer products are effective at eliminating the appearance of efflorescence if applied during initial construction and before any saturation of the system with rain or moisture. Deep penetrating, solvent base, breathable sealers are most effective like *ProSoCo's Salt Guard*.