AVOIDING THE NEMESIS OF EFFLORESCENCE

WATERPROOFING INSIDE AND OUT
THE LONG TERM SOLUTION
THIS PRESENTATION DISCUSSES:

- Water The Most Powerful Force On Earth
- Efflorescence Types, Appearance And Effects
- Where Efflorescence Occurs And Its Pathway There
- What It Is And What It Can Become
- The Mechanics And The Chemistry
- Capillarity At Work In Conjunction With Salts Or Internal Transfer
- Salt Introduction From Seaside or Man Made Conditions
- Materials Subject To All Mechanisms
- Waterproofing Is The Only Answer To That Which Has Happened And To That Which Will Happen
WATER, THE MOST POWERFUL FORCE ON EARTH

REGARDLESS OF ITS FORM
As an ocean wave, or a single drop
WATERS PROPERTIES ARE AMAZING

• Expands when its heated and expands when it freezes
• It is acidic, neutral and alkaline at the same time.
• It is polar, meaning it is both negatively and positively charged.
• It is the world best solvent.
• It has the highest rate of absorption of heat before vaporization of any liquid.
• One drop contains three million molecules.
• It rises in tree's over two hundred feet high without a sound.
• It can theoretically travel 6 miles in concrete.

IN CONCRETE WATER IS FRIEND AND FOE.
YOU CANNOT MAKE CONCRETE WITHOUT IT,
BUT ONCE MADE IT NEEDS TO LEAVE AND NOT RETURN.
Efflorescence Types, Appearance And Effects

EFFLORESCENCE
EFFLORESCENCE, WHAT IS IT?

- Efflorescence is a deposit of soluble salts, delivered by water to the surface, usually white in color which can appear on the surface of concrete, masonry, stone, wood, plasters and tiles.
- Efflorescence cannot occur without the presence of water.
- Water is the delivery system for all efflorescence in all materials.
WHAT TYPES OF MATERIALS CAN IT AFFECT?

Wood

Concrete

Stone

Masonry
ITS JUST FLAT UGLY
Primary efflorescence comes from water being driven out of a cement based product by the heat of hydration, or water permeating into the material and leaving through the point of least resistance, while carrying the free alkali or CH with it.

Secondary efflorescence is the result of natural, such as dissolved ground minerals/salts, and man made influences such as deicing salts on roads and bridges. It will naturally occur when water wicks by capillarity into a cementitious product and leaves through the point of least resistance such as the grout lines above the water line in a swimming pool or spa.

Although this is called secondary efflorescence it remains the primary or predominate type we see most often.
PRIMARY EFFLORESCENCE

Efflorescence forms from the free alkali after placement or manufacture in the presence of moisture.
SECONDARY EFFLORESCENCE

Man made or natural salts dissolved in water create secondary efflorescence.
Where Efflorescence Occurs And Its Pathway There

THE PATHWAY OF EXISTENCE
WHERE DOES IT OCCUR?

- Anywhere the conditions for penetration, permeation, capillarity, or absorption of water into a cement based material are present results in all types of conditions.
IN DIFFERENT WAYS (UP THE WALL)

IN A POOL

Water Comes Out Bringing The Efflorescence With It

Water Line

Water Penetrates Into Grout, Thin-set, Pool Wall & Travels Up By Capillarity/Wicking

Section Thru Pool Wall At The Tile Line

LIKE THIS
IN DIFFERENT WAYS (THRU THE WALL)

IN A FOUNTAIN

Water Comes Out
Bringing The
Efflorescence
With It

Water Penetrates Into
Porous Block, Mortar &
Plasters by Absorption
and Capillarity

Section Thru Fountain Wall & Floor

LIKE THIS

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IN DIFFERENT WAYS (UNDER THE PAVER)

On Pavers

Like this

Water Comes Out Bringing The Efflorescence With It

Water Penetrates Into Sand & Travels Up By Capillarity/Wicking Thru The Pavers

Section Thru Brick Pavers Over Sand
IN DIFFERENT WAYS (BASEMENT WALLS)

IN BASEMENT (Block Walls)

Like This
IN DIFFERENT WAYS
(CONCRETE BLOCK & STUCCO)

Above Grade Concrete Block

Like This

Water Comes Out Bringing The Efflorescence With It

Water Penetrates Into Porous Block and Mortar by Hydrostatic Pressure and Capillarity

Section Thru Block House Wall & Slab
IN SUSPENDED POOLS (ABOVE GROUND)

Above Ground Suspended Pools

- Water migrating from the cold joint in the seam between the vault wall of the pool and the pool deck itself.

Like This
IN ARCHITECTURAL WORKS OF ART (MONASTERY KAUA'I)

By Penetration and Permeation

- Water migrating from the topside leaching out efflorescence creating unsightly appearance on an otherwise magnificent structure.
IN BRICK EXTERIORS (BUILDING STRUCTURES)

Collected roof water

- Here primary efflorescence is taking place from the top down on the building as shown. Notice the parapet walls are not leaching themselves but just below at the roof level.
IN RETAINING WALLS

By capillary action

- Here the water is migrating by capillarity from the ground and possibly the backside of the ground itself.

Like this
ON CONCRETE FLOORS

By absorption and capillarity

- Here water is making its way to the surface of the concrete slab and forming dendritic crystals in the surface of the concrete itself.
ON CLAY TILE FLOORS

By absorption and capillarity

- Here salts are making their way through the Saltillo or clay tiles and depositing the salts at the surface.

Like this
ON LIMESTONE STRUCTURES LIKE BASEMENTS

By absorption and migration

- Here the efflorescence has worked its way to the surface of the limestone ultimately breaking down the surface of the stone itself.

Like this
ON FOUNTAINS

By capillarity, permeation and absorption

- This fountain is exhibiting all facets of water penetration and migratory effects.

Like this
ON EXTERIOR STAIRCASES

Deicing salts at work

- Here salts have permeated the tiles and are discoloring the face and the grout as well.

Like this
The surface on the outside of the foundation wall is scaling and flaking because of moisture, salts and freeze-thaw cycles.
Here you can see where the form ties were not sealed and water has created the circular pattern around the hole itself. The outward pattern demonstrates perfectly the migratory and expansive effect water can have.
On this bridge abutment the efflorescence is present and as well as the spalling and cracking that is now taking over.
ON POOLS

From wet and dry cycling of the features on this pool water fountain.

Permeating from the interior of the pool itself.
ADHESION LOSS DUE TO WATER

Under vinyl flooring on a concrete slab shown by the white material.

Overhead on the underside of a concrete slab causing coating failure by blistering.
What It Is And What It Can Become

ANALYSIS OF ITS FORMATION
WHAT IS IT REALLY?

• In French, efflorescence means to “flower out”. It is the loss of the water of crystallization, from a hydrated or solvated salt, to the exposure to the atmosphere or air.

• In Europe it is referred to as “rising damp”

• Water migrates through a process of wicking, capillarity or hydrostatic pressure/osmosis whereby as the water travels, calcium hydroxide that is not bound in the matrix, is carried out, and by exposure to the atmosphere, the water evaporates and leaves the crystallized product behind.

• Secondary efflorescence are the result of concrete poisons such as chlorides, being saline solutions, penetrate into the concrete and begin to dissolve the cement paste and free alkali then permeating through the matrix to the point of least resistance. Virtual stalactites and stalagmites can form under these conditions putting the integrity of the structural elements at risk because of its outward pressures and deteriorative effect on cohesion of the matrix.
WHAT DOES IT BECOME?

Free Alkali + Water → Efflorescence (calcium hydroxide CH) + CO2 → Calcium Carbonate

CH + CO2 → Calcium Carbonate
IN NATURE IT FORMS STALACTITES AND STALAGMITES

Like This
IN SALT LADEN REINFORCED CONCRETE

Stalactites of salts

Here a crack in reinforced concrete slab is leaching out the salt products forming the stalactites of salts and minerals.

Like This
THE MECHANICS AND THE CHEMISTRY

HOW IT GETS THERE
WHAT IS THE KEY ELEMENT?

• Hydrostatic Pressure/ osmosis / Capillarity / Wicking = Moisture Transmission
WHAT WATER PROPERTIES CREATE CAPILLARY ACTION?

Water is an essential inorganic compound with the following properties:

- **Polar**
  - Hydrogen molecules are positive
  - Oxygen molecules are negative

- **Wicks**
  - Water has capillary action based on the cohesion and adhesion of the water molecules

- **Cohesion**
  - Polar water molecules tend to stick together with hydrogen bonds

- **Adhesion**
  - Water molecules tend to stick to polar surfaces such as glass
WHAT WATER INTERACTIONS PLAY A PART?

Cohesion + Adhesion → Capillarity
WHAT IS ADHESION AND COHESION?

ADHESION is when molecules stick to a different kind of molecule such as glass.

COHESION is when molecules attract or stick to each other.
Capillarity At Work In Conjunction With Salts Or Internal Transfer

THE FORCES AT WORK WITHIN AND THE RESULTS
THE WATER FORCES AT WORK WITHOUT SALTS

Concrete Surface Erosion From Water Itself

Mortar and Brick Surface Erosion From Water and Freeze-Thaw Cycling
THE FORCES AT WORK WITH SALTS INVOLVED

Here the concrete column where exposed to de-icing salts has permeated the lower portion of the column causing the oxidation of the reinforcing steel resulting in concrete spalling.

On the left hand side of the white pile of efflorescence is where ocean water dripped out of a boat on a concrete garage floor. The deterioration is self-evident when compared to the right.
THE EFFECT OF WATER IN POROUS MATERIALS

Moisture Without Salts Rely On Alkali To Create Efflorescence

Ground And Or Surface Water Wicking By Capillarity Into The Concrete Matrix
WHEN DISSOLVED SALTS ARE ADDED

Evaporation Of Moisture Into The Atmosphere Reduces As Salts Accumulate Below The Surface

Ground Water Dissolves Mineral Salts In The Soil And In Turn Is Then by Capillarity Wicks Into the Concrete Matrix
SALTS HAVE AN AFFINITY FOR WATER AND WATER HAS AN AFFINITY FOR SALTS

The Ever Increasing Salt Concentration Attracts More Water To Bring Equilibrium To The Condition

Additional Water Is Attracted To The Salt Concentration
The Waters Affinity For Salts Creates Hydrostatic Pressures That Can Range From 3000-5000 psi which Is Also Known As “Osmosis”

The Capillarity Pressures Can Range From 300-500 psi Which Increases As Mineralization Occurs Within The Matrix
EFFLORESCENCE, SURFACE DETERIORATION, AND SPALLING ARE THE RESULTS

Surface Deterioration and or Spalling Are The Result Of The Internal Pressures Breaking The Materials Cohesive Bond

When The Increased Pressure Exceeds The Cohesive Strength Of Most Porous Material It Literally Blows or Breaks Apart
Salt Introduction From Seaside or Man Made Conditions

SURFACE OR TOPICAL MECHANISMS
WHAT ABOUT POROSITY AND PERMEATION?

Permeability is the open pore spaces allowing moisture transmission into the matrix.

Porosity is the distance between aggregates and cement paste within the matrix that allows the moisture transmission to continue thru.

Concrete Matrix Section Thru
CONCRETE PERMEABILITY OR ABSORPTION ON THE SURFACE OF THE MATRIX

A cast concrete slab that to the naked eye appears to be sound and solid. At 130x magnification it renders an entirely different view.
DIFFERENT WHEN YOU TAKE A CLOSE LOOK

The broken edge of a cast piece of concrete as it appears to the naked eye.

At 130x magnification it bears a whole new light on what we really are looking at.
REMEMBER THAT **ONE DROP OF WATER**
CONSISTS OF: **THREE MILLION MOLECULES**

IF THIS MODEL REPRESENTS 100 MOLECULES THEN THE POINT OF A NEEDLE COULD NOT PLACE THREE MILLION MOLECULES INTO THIS DROP OF WATER

NOW RELATE THE MOLECULE TO THE SIZE OF THE PHOTO MICROGRAPH AT 130X, WHERE THE WATER MOLECULE IS SHOWN
ITS LIKE WALKING IN THE GRAND CANYON

Comparatively

Our model

The Grand Canyon
WATER WILL GO WHEREVER IT WANTS, IF YOU LEAVE THE SPACE OR PLACE

A Set Of Steps Where The Excess Concrete Was Ground Off Revealing The True Substrate

What Appears To Be A Solid Monolithic Concrete Structure Is Not. Never Judge A Book By Its Cover
WHAT PART DOES EXPANSION PLAY?

Whether expanding because it turns to ice, or expanding when heated turning into vapor pressure, it is moving outward with force. Regardless of the material, the force can move or lift it off.

As it expands, it needs more space.
When water freezes it expands as shown in the six sided hexagonal molecule model, which is diametrically different than the liquid model below.

The picture below shows the result of either failure to waterproof or surface waterproofing that is not vapor permeable or breathable resulting in surface loss and spalling.

The Stable Hexagonal Arrangement Of The Hydrogen Bond Between Water Molecules Reveals A Perfect Six Sided Symmetry In Every Snowflake
WATER EXPANDS WHEN HEATED

When Water is Heated to Reach “The Heat Of Vaporization”, it expands as shown in the molecular model when compared to the linear liquid model. This results in vapor pressure which can cause lifting of coatings and waterproofing because of built up vapor pressure within the matrix aka: Steam.
ONE MORE ELEMENT: VAPOR PRESSURE AND EVAPORATION

ON HORIZONTAL SURFACES
Here vapor pressure is pushing the salts out of the deck non water proof deck in a seaside condition.

ON VERTICAL SURFACES
Materials Subject To All Mechanisms

COMBINED EFFECTS
NOW COMBINE THE EFFECTS IN WATER

Piling exhibiting concrete spalling in fresh water

Piling exhibiting spalling in salt water
NOW COMBINE THE EFFECTS ABOVE THE WATER

Oxidation of reinforcing steel on the underside of a concrete parking deck.

Accumulated efflorescence and column cap cracking from moisture intrusion and efflorescence production.
HOW TO PREVENT OR STOP IT WHEN POSSIBLE

Waterproofing Is The Only Answer To That Which Has Happened And To That Which Will Happen
HOW DO YOU STOP IT?

Act on the key element by creating a barrier

- Wicking
- Capillarity
- Hydrostatic Pressure

Waterproof Barrier

Moisture Passes By Vapor Only
WHAT IS A WATERPROOF BARRIER?

- A proper waterproof barrier creates a means to stop water capillarity, penetration, permeation, wicking and hydrostatic pressure from allowing water to permeate the cement based matrix and in turn create a substrate that is:

  DRY AS A BONE
WHAT IS WATERPROOF?

• Waterproof is the inability of water and dissolved constituents to penetrate, permeate, be absorbed, or wick through the matrix of the material applied to the substrate and or surface of the material applied to.

• This material may in turn create a waterproof or capillarity break to stop the delivery or capillarity of the water predicated on its location when applied.

• These principles will stop efflorescence in its tracks as long as a monolithic, pinhole free membrane is developed in the materials application and the mechanical principles described have been mitigated.

• In the case of existing conditions where efflorescence is present, internal matrix conversion may be necessary to limit the hydrostatic/osmosis pressures that occur that can break apart the cohesion and adhesion of the waterproofing material.

• Absolute waterproofing may require the application of combined systems to achieve the final goal of 0 permeability except vapor.
WHAT PRODUCT FACTORS YIELD A PREMIER WATERPROOFING SYSTEM?

INTERNAL WITHIN THE SUBSTRATE
- Higher density
- Internal components (materials within the mix) to regulate and limit the conversion of free alkali by water to travel to the surface

ADHESION TO THE SUBSTRATE
- Superior adhesion to limit the effect of hydrostatic and capillarity pressures developed by the water itself.
- Superior adhesion to the substrate to assure permanence as well as other materials to the waterproofing such as plaster.

FLEXIBILITY OR COHESION
- Allowing substrate movement to accommodate pressures and or movement developed by containment and the coefficient of volumetric expansion when temperature is involved.

RESISTANCE OF THE WATERPROOFING
- Resistance to chemical attack from destructive components.
- Resistance to ultraviolet exposure by sunlight degradation.
WHAT ABOUT FIELD APPLICATION AND USE?

EASE OF USE

- Simplistic mixing when more than one component
- Simplistic application regardless of product type
- Minimal investment in application equipment
- Uniformity in all applications as desired
- Repeatable in multiple applications once understood

Compatibility

- Is compatible with virtually all substrates
- Is compatible with other materials utilized within the scope of work
- Is compatible to assure an integral system beyond existing boundaries
WHEN WATERPROOFED TO ITS FINAL POSSIBILITY

A Waterproof System Will:

- Reduce if not eliminate long term maintenance costs
- Provide protection and value to the structure extending its life way beyond structures that are without it.
- Improve and extend the life of other coatings and or materials placed over it.
- Not discolor or age with time and exposure to the elements
- Provide beauty and permanence
- Prevent the plague of mold and mildew
- Most importantly provide value in safety, health and longevity for the ultimate consumer.
ADDITIONAL FACTORS

**SINGLE SOURCE SUPPLIER**
- A single source supplier and or manufacturer who understands all facets of the problems and has the technology in place to solve the problems.

**INTERNATIONAL AVAILABILITY**
- Providing their services worldwide as these problems exist everywhere.
WANTS TO THANK YOU FOR THE OPPORTUNITY TO SHARE OUR EXPERIENCE AND TECHNOLOGICAL EXPERTISE WITH YOU

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