ALLANA BUICK & BERS

Making Buildings
Perform Better

Life Expectancy and Longevity of Buildings and Assemblies

Condo Council of Maui 2016 Seminar

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Life Expectancy of Buildings and Assemblies

- **Life expectancies of building systems and assemblies:**
  - Wood/Steel/Concrete/masonry type buildings
  - Windows and insulated glass
  - Vinyl and Aluminum window frames
  - Plumbing and sewer pipes
  - Aluminum hand rails
  - Concrete
  - Lanai and podium waterproofing
  - Roofing systems
  - Sealants and caulking
- **Steps to ensure optimized lifespan:**
  - Understanding aluminum anodization and longevity
  - Understanding concrete spall mechanism and repair
  - Understanding plumbing pipe repairs
    - Pipe replacement
    - Pipe lining technology: When and why
    - Optimizing sealants, coatings and paint

Life Expectancy of Buildings and Assemblies

- **Life expectancy of building:**
  - IRS's definition – 39.33 years
  - In reality, buildings can last from 50 to 1000 years

- **Lifespans of historic buildings by type:**
  - Wood framed low rise, 50 - 250 years
  - Mass masonry, 100 - 500 years
  - High-rise, > 100 to 250 years

Long Lasting Building Assemblies

- **The number 1 contributing factor for longer lasting assemblies is good construction, free from defects**
- **The number 2 factor is system/material selection**
- **The number 3 factor is superior design**
- **Characteristics of long lasting building assemblies:**
  - Roofs that can last over 30 years and are not dependent on “maintenance” or repairs to keep them water tight
  - Horizontal waterproofing assemblies like podiums, and roof decks are reliably waterproofed and constructed to last for the life of the building
  - Exposed horizontal waterproofing systems like Lanais can last between 5 years and 20 years
  - Below grade waterproofing is built to last the life of the building
  - Exterior skin can last for the life of the building (50 to 500 years)
  - Sealant replacement cycle is limited to 20+ years and water intrusion is not entirely sealant dependent

Life Expectancies of Building Assemblies

- **Typical "well constructed" building assemblies:**
  - Low sloped roofs that can last over 30 years and are not dependent on "maintenance" or repairs to keep them water tight
  - Protected waterproofing assemblies like podiums and plazas with concrete or pavers, can last for the life of the building but most don't
  - Exposed, trafficable horizontal waterproofing systems for Lanai and walkways can last between 5 years and 20 years before re-coating is required
  - Protected below grade waterproofing is built to last the life of the building
  - Exterior skin can last for the life of the building (50 to 500 years) with maintenance such as sealants and gasket replacement
  - Sealant replacement cycle is limited to 20+ years and water intrusion is not entirely sealant dependent

Definition of Reliable Exterior Envelope

- Reliable = Dependable, leak free performance
- Building leaks are the number one reason for law suits
- The building envelope needs to “reliably” provide a barrier against water intrusion and air leakage and thermal insulation for the life expectancy of the assembly
- Reliable building envelopes don’t depend on routine maintenance to keep them water tight
- Reliable building envelope assemblies have “belt and suspenders” to keep the water from going in or around the area that it is not intended
- Reliable assemblies utilize materials and design that are “proven” to work
- Reliable assemblies have “predictable” life expectancy

Life Expectancies of Fin Style Windows

- **Fin style windows are generally used in low rise / low water intrusion construction**
- **Fins are needed to integrate windows with building paper and other weather resistive barriers**
- **Non-fin style windows are generally aluminum, used for commercial and high rise buildings typically with unitized and pre-glazed frames. More difficult to integrate with weather resistive barriers**
- **Frame materials include:**
  - Wood
  - Aluminum
  - Vinyl
  - Fiberglass
  - Both vinyl- and aluminum-clad substrates

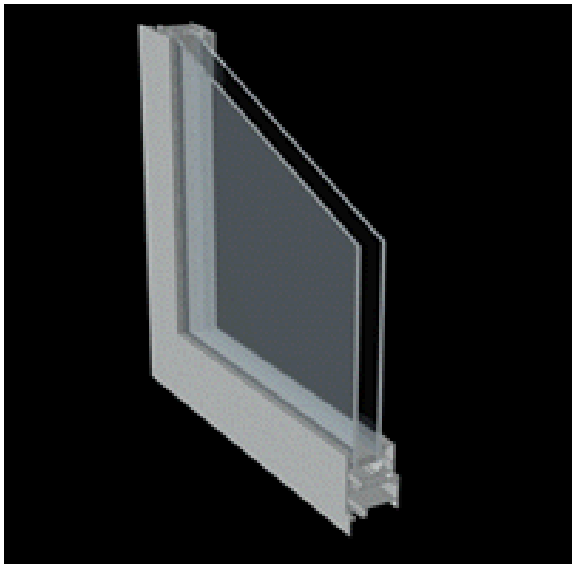
Window Frame Types

- **Wood**
  - The traditional window frame material
  - Wood frames are high maintenance, they require sanding and staining, and the outer frame may require re-finishing every few years

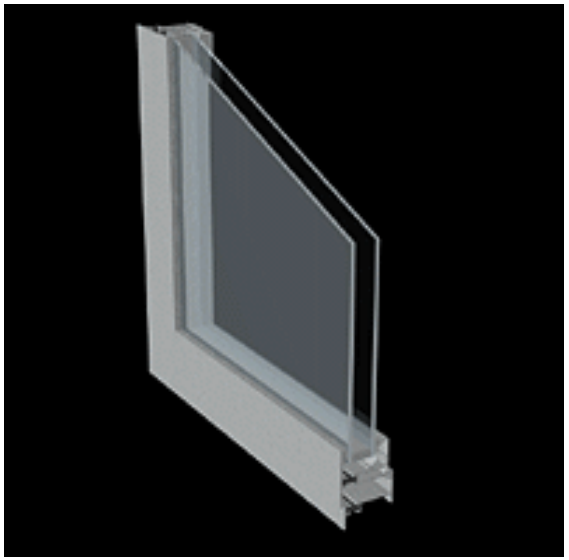
- **Aluminum Clad Wood**
  - Clad the exterior face of the frame with either vinyl or aluminum, creating a permanent weather-resistant surface

Window Frame Types

- **Aluminum**
  - Aluminum window frames are light, strong, and durable, but with high thermal conductance. They readily conduct heat, greatly raising the overall U-factor of a window unit

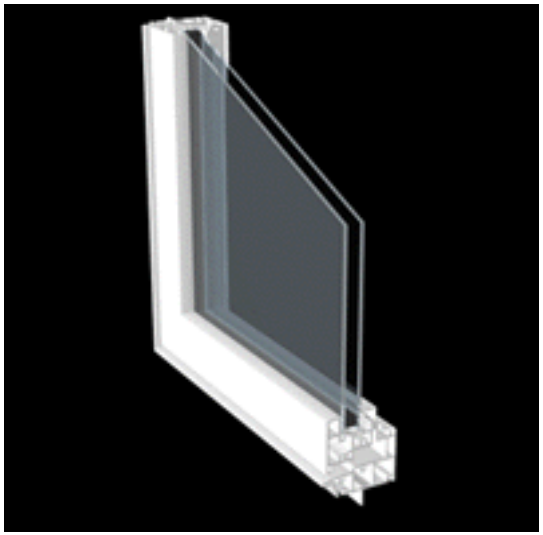


- **Aluminum with Thermal Break**
  - The most common solution to the heat conduction problem of aluminum frames is to provide a thermal break by splitting the frame components into interior and exterior pieces and use a less conductive material to join them

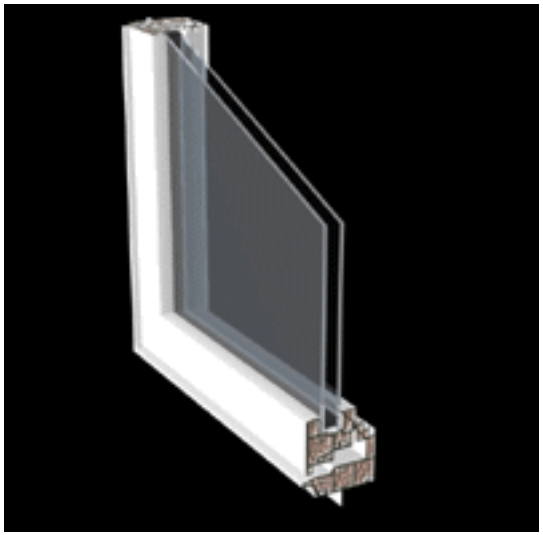


Window Frame Types

- **Vinyl**
  - Vinyl does not conduct heat very well and is therefore considered a good thermal insulator
  - Vinyl comes in different wood grain finishes and does not require painting or finishing



- **Insulated Vinyl**
  - In insulated vinyl frames, the non-draining hollow cavities of the frame are filled with insulation making them thermally superior to standard vinyl and wood frames. Usually these high performance frames are used with high performance glazing



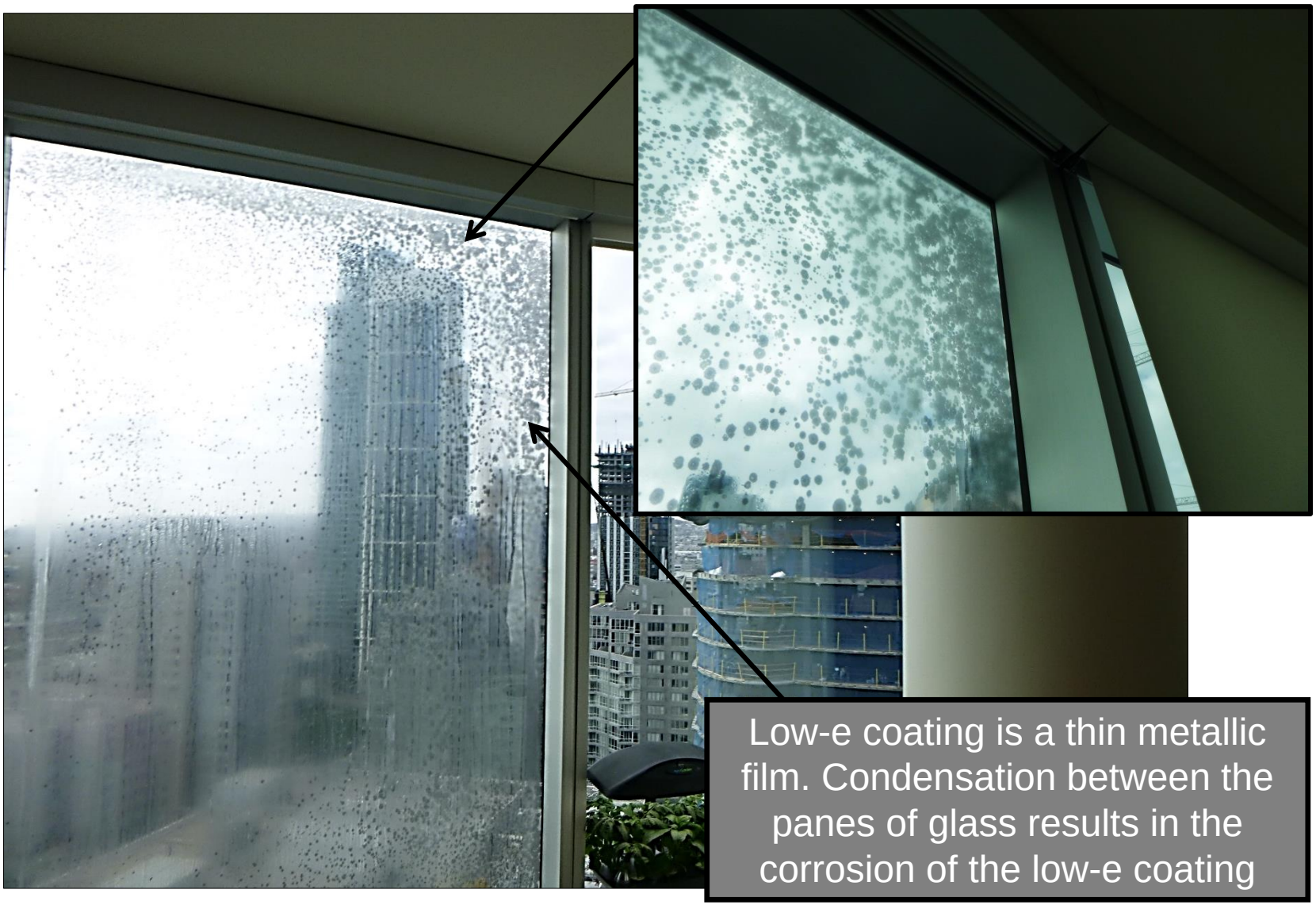
What is Working and What is Not Working?

- **Generally, “Fin” or “Nail on Flange” type windows are not performing well due to poor design and or use of sub-standard materials**
  - **Glazing Seals:** Commercial curtain walls and storefronts use Butyl or pre-shimmed tape + Silicone sealants: Fin-style windows generally use “acrylic” foam tape and not silicone sealant
  - **Window Frame Corners:** Aluminum Fin style window corners are generally sealed with “narrow joint acrylic sealants”. Commercial glazing utilize larger joint, silicone sealants
- **Vinyl window frames are “welded” and generally perform much better than aluminum fin style frame corners**
- **Windows are tested and manufactured to smaller size and are often mulled together to form a large windows. Mulled windows have inherent issues and risks**

Insulating Glass Seal Failure

- **Dual pane windows are used for insulation**
- **Dual panes have air gap filled with Argon or inert gas and sealed around perimeter.**
- **When glazing seal fail, air and moisture moves in and can condense inside panes**
- **Premature failure of sealed units is usually caused by:**
  - Poor design and use of poor quality materials used to seal two panes of glass together
  - Poor workmanship on an individual unit during fabrication
  - Poor frame design which will allow the unit to sit in a high moisture environment

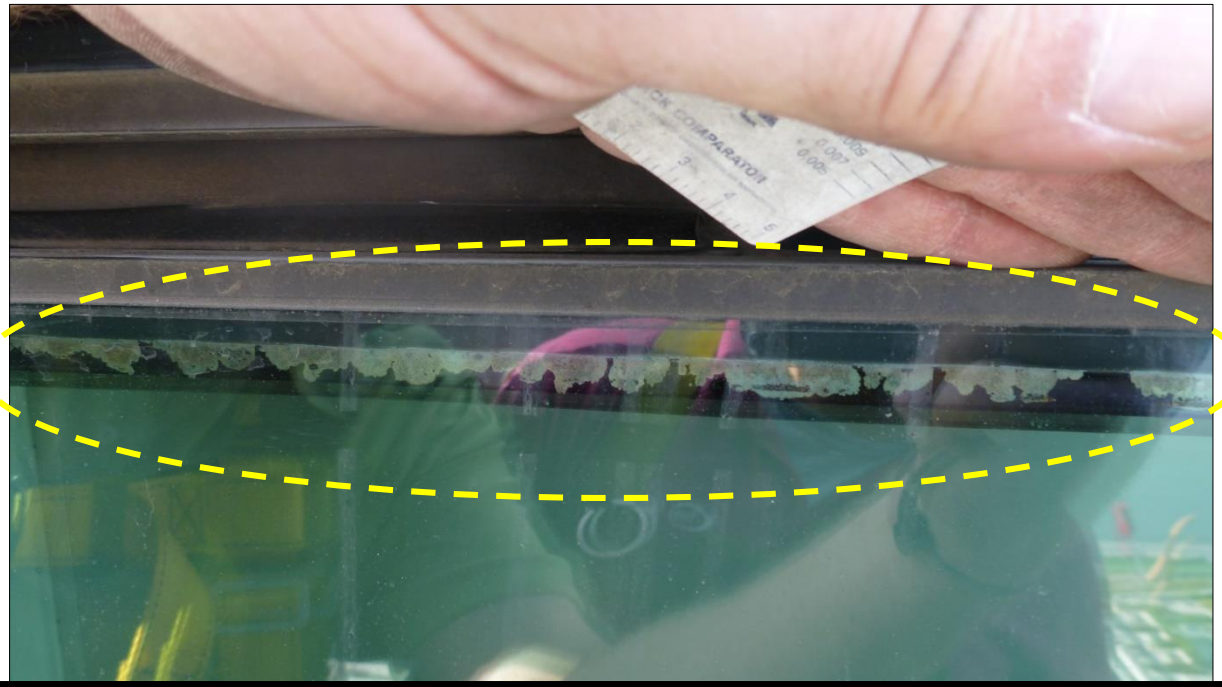
Insulating Glass Seal Failure



Low-e coating is a thin metallic film. Condensation between the panes of glass results in the corrosion of the low-e coating

Building D, Unit 28F

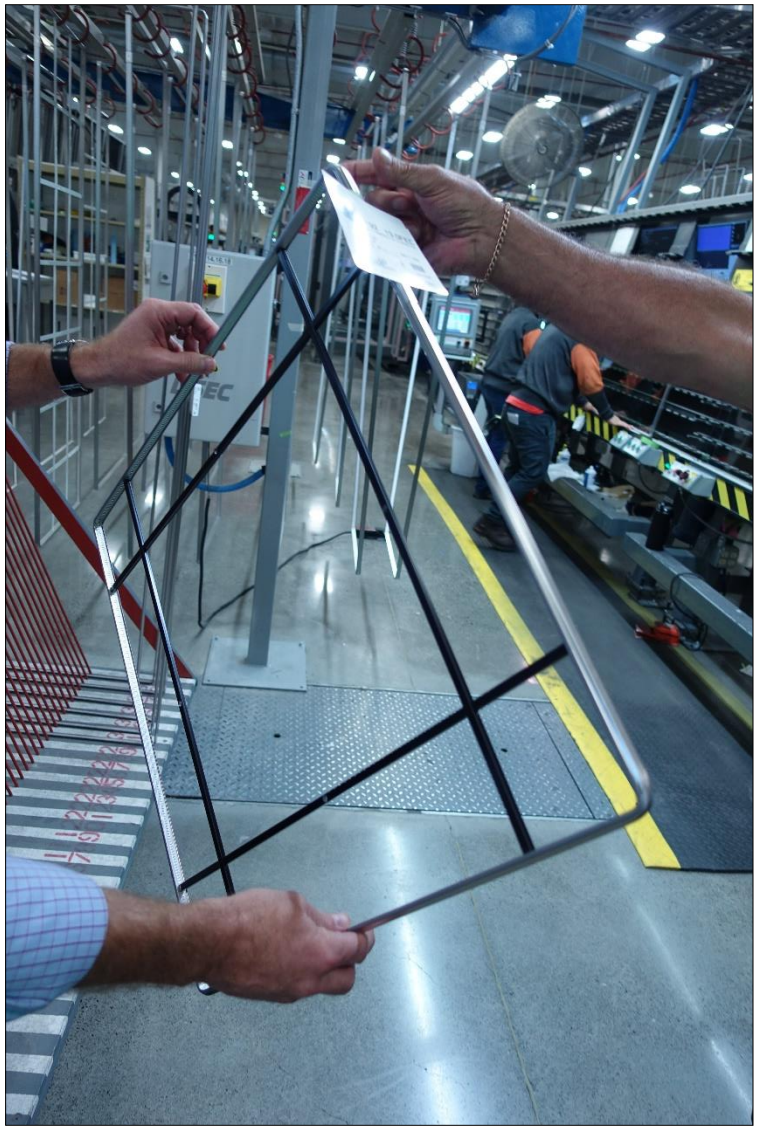
Glazing Seals Can Fail For A Number Of Reasons



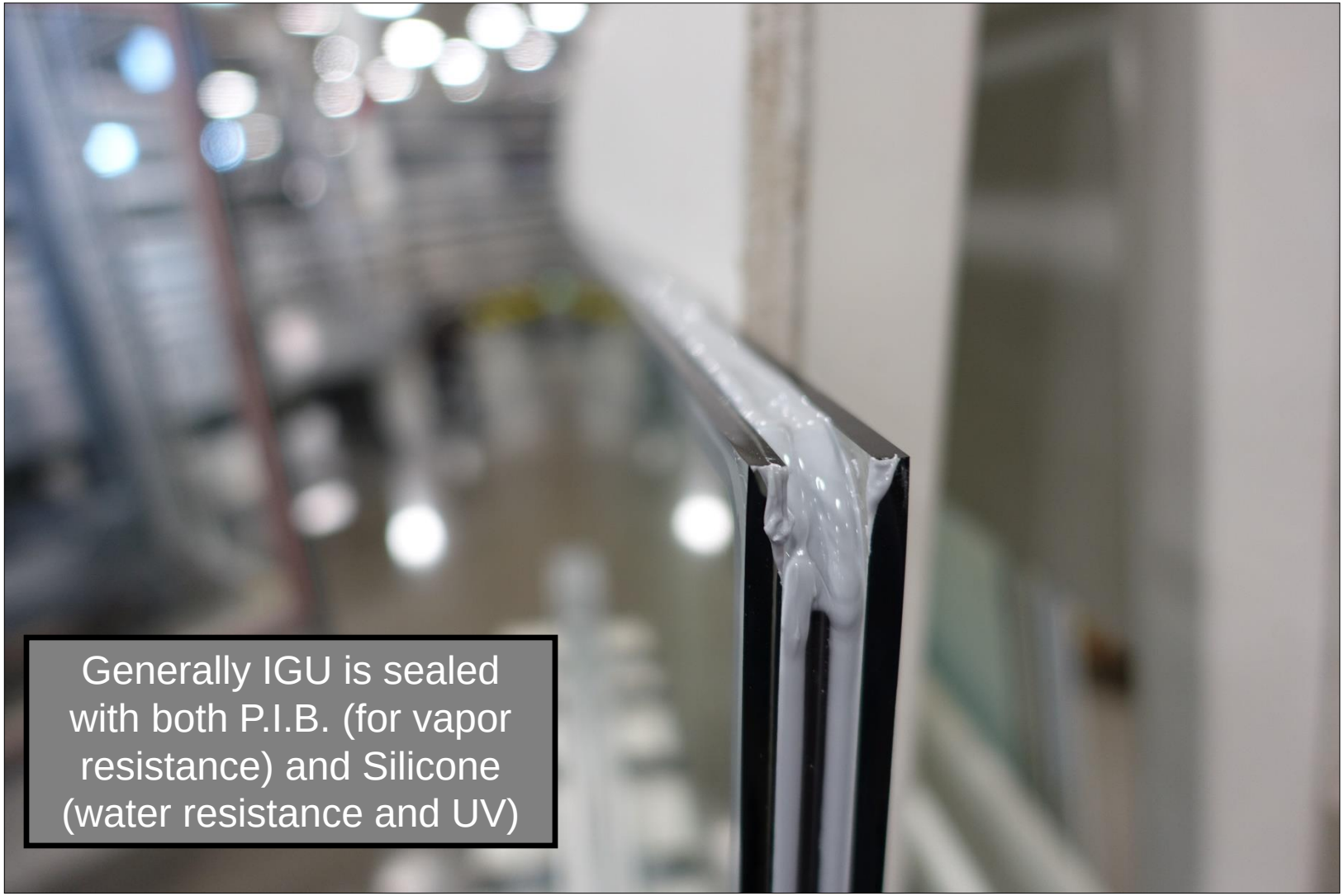
Between panes of glass, the air space is filled with desiccated air or an inert gas like Argon. IGUs are typically composed of a “dual seal” system with a primary seal being P.I.B. (Polyisobutylene) with a secondary seal of silicone (preferred) or polysulfide

Failure can occur if the silver coating is not “edge deleted”. Edge of the glass can start corroding and corrosion can spread to the inside, by-passing the seals

IGU Seals, Stainless Spacers Last Longer



IGU Units Sealed With Dual Sealants



What is a Mulled Window?

- When 2 to 3 windows are joined together

What is a Mulled Window?

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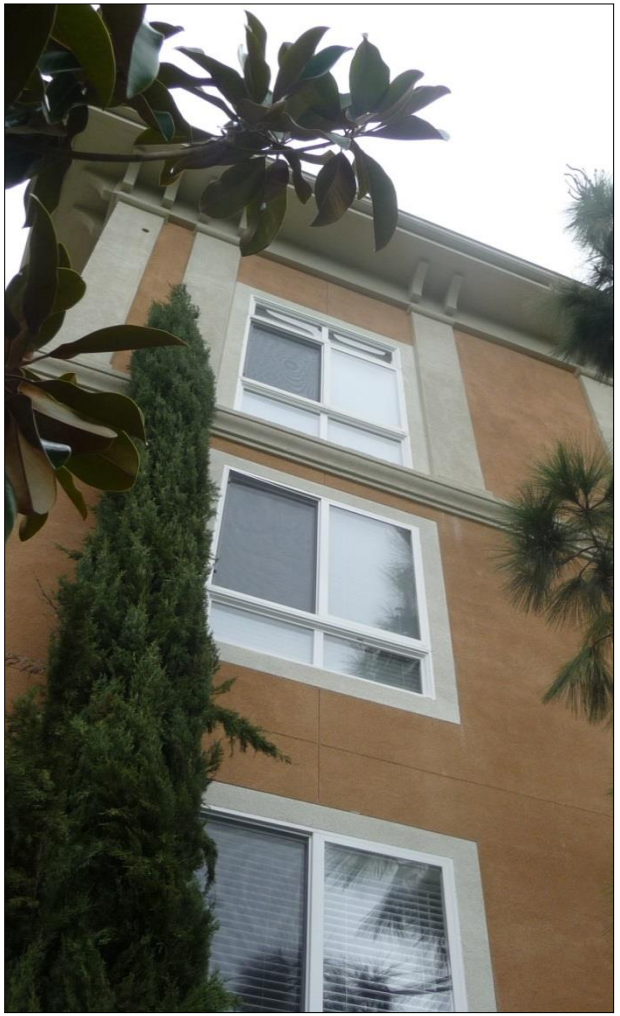
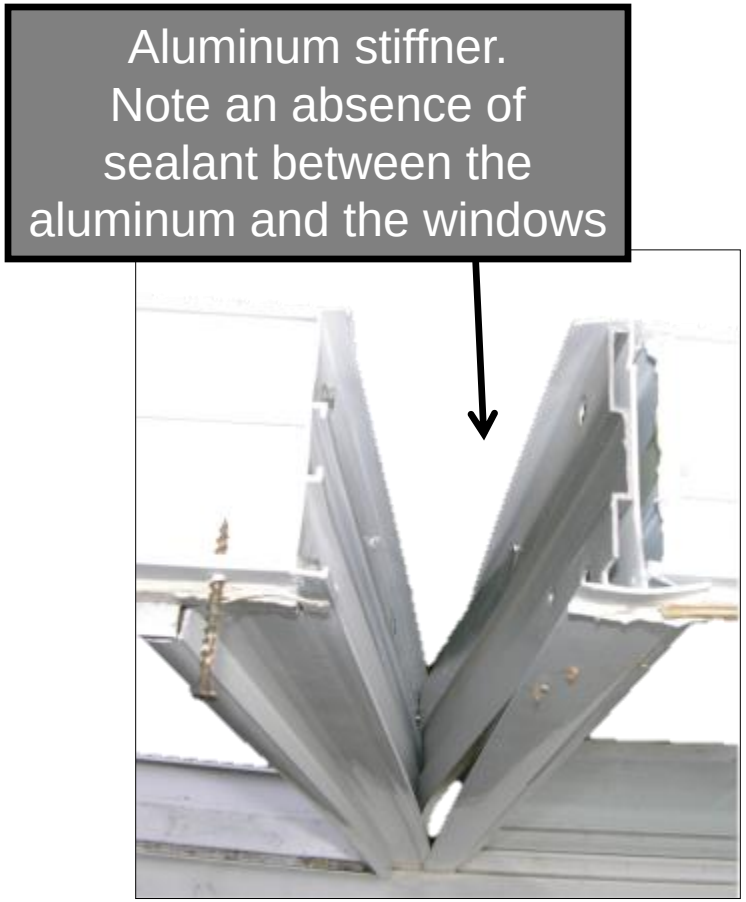


Water Leaks Through "Mulled" Joints

- **Mullion is a stiffner used to join window frames together**
- **Mulled joints can inherently allow water intrusion due to a number of issues**
- **Often only single windows are tested under AAMA 501 protocol and not the "mulled" configuration**
- **If you must specify mulled windows, be sure to specify that the window must be tested in it's "mulled" condition (AAMA 450)**



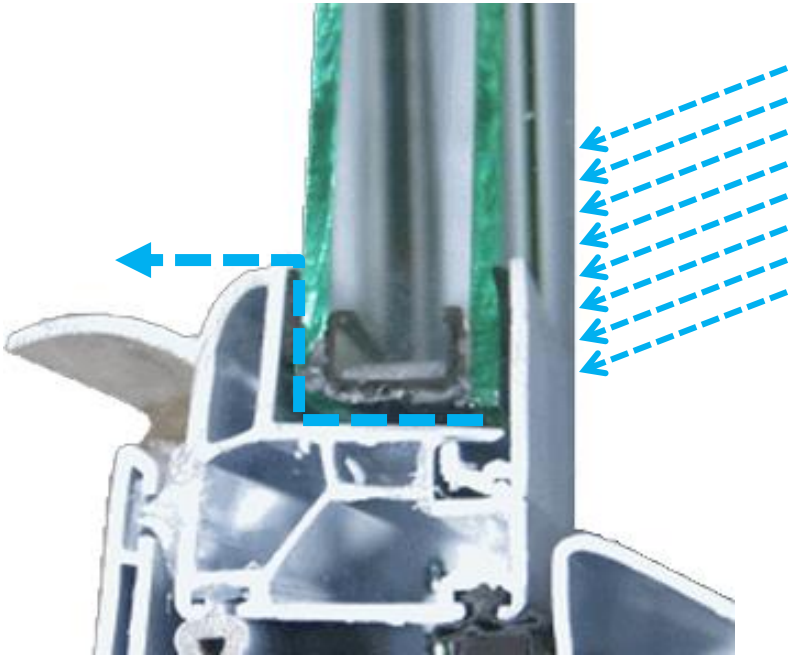
Mulled windows separated

Horizontal and Vertical Mullion Failures

Horizontal and Vertical Mullion Failures

Water Leaks Through Glazing Seals

- "Glazing seal" refers to the seal between the glass and window sash
- Commercial windows use tape with adhesive backing on two sides and silicone heel or cap beads for glazing seals
- Fin style windows often only use acrylic tape and no wet silicone
- Acrylic tape can break down from UV and water
- In some cases window sashes can overflow with just a light spray



Glazing Failures And Resultant Leak

Glazing (Glass to Frame) Failures And Leak

Glass Has Been Removed, Foam Tape Exposed

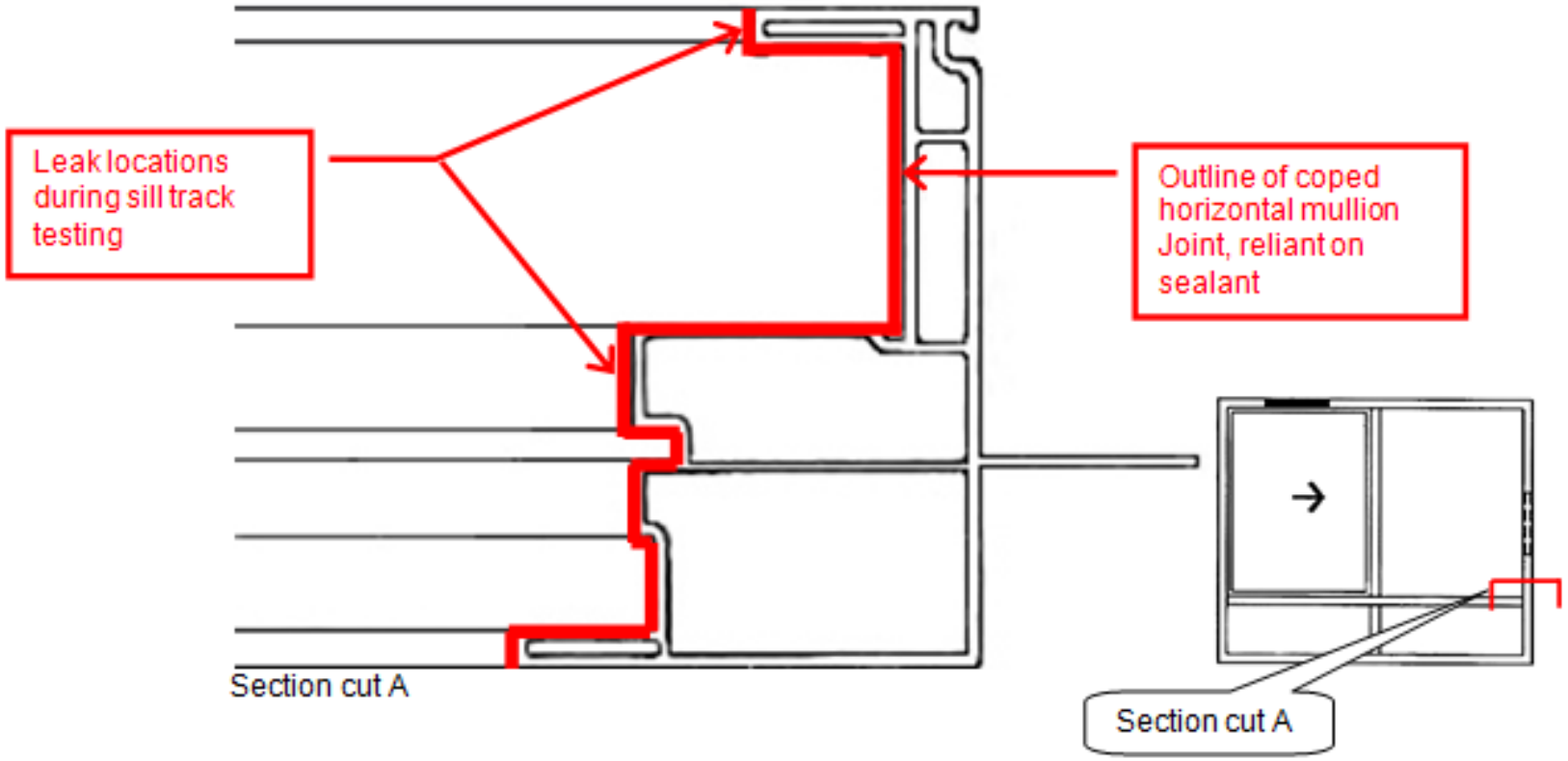
Coped Joint (Horizontal to Vertical) Failure

A = Manufacturer attempted to seal leak by pumping foam at coped joint

B = Clear silicone sealant, failed attempt to seal coped joint

Coped Joint At Intermediate Horizontal Mullion

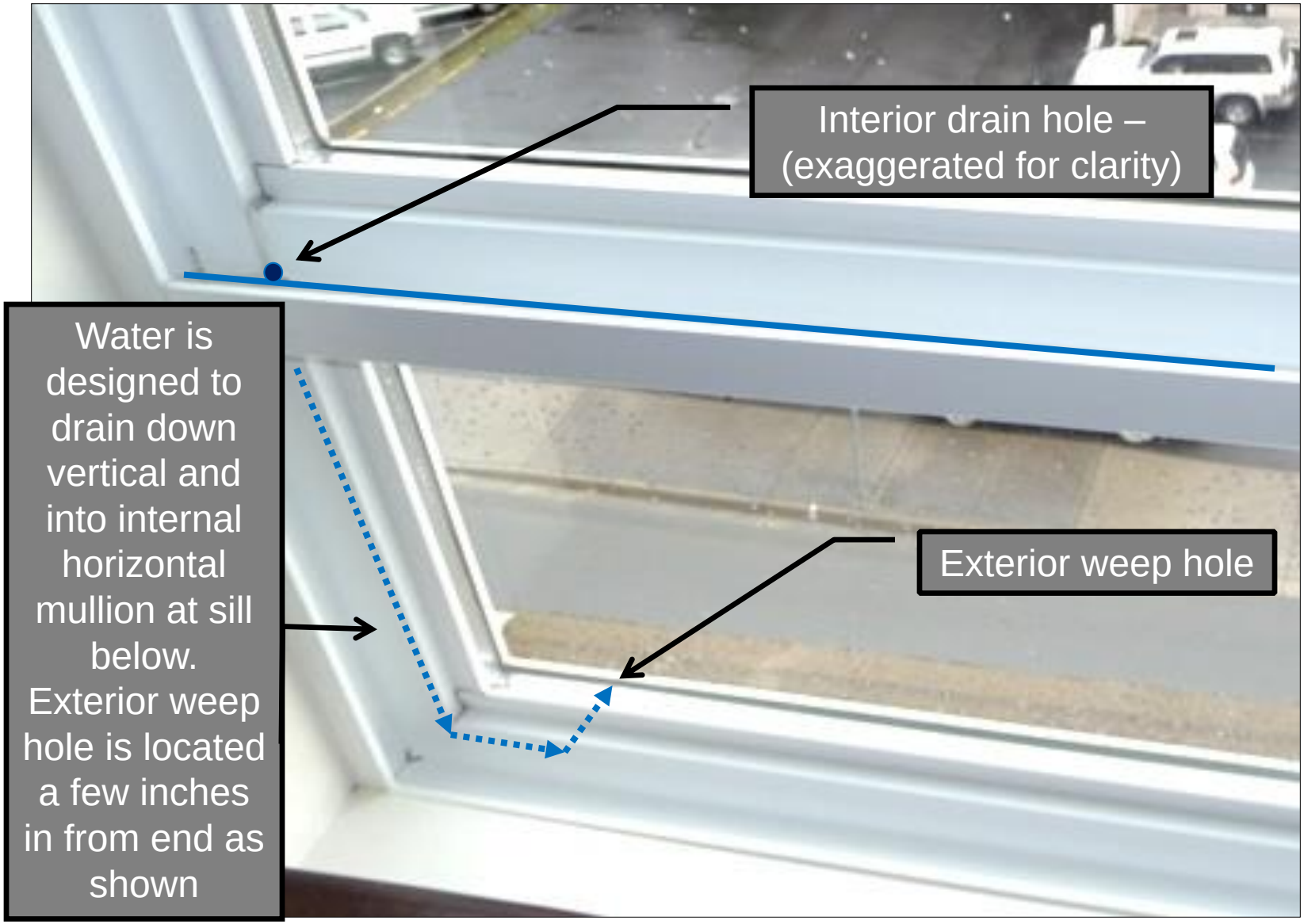
- The sealant-dependent coped joint in the horizontal mullion has failed and allows water to leak through this junction and accumulate in the lower fixed “dry” sill track, which is not designed to manage water



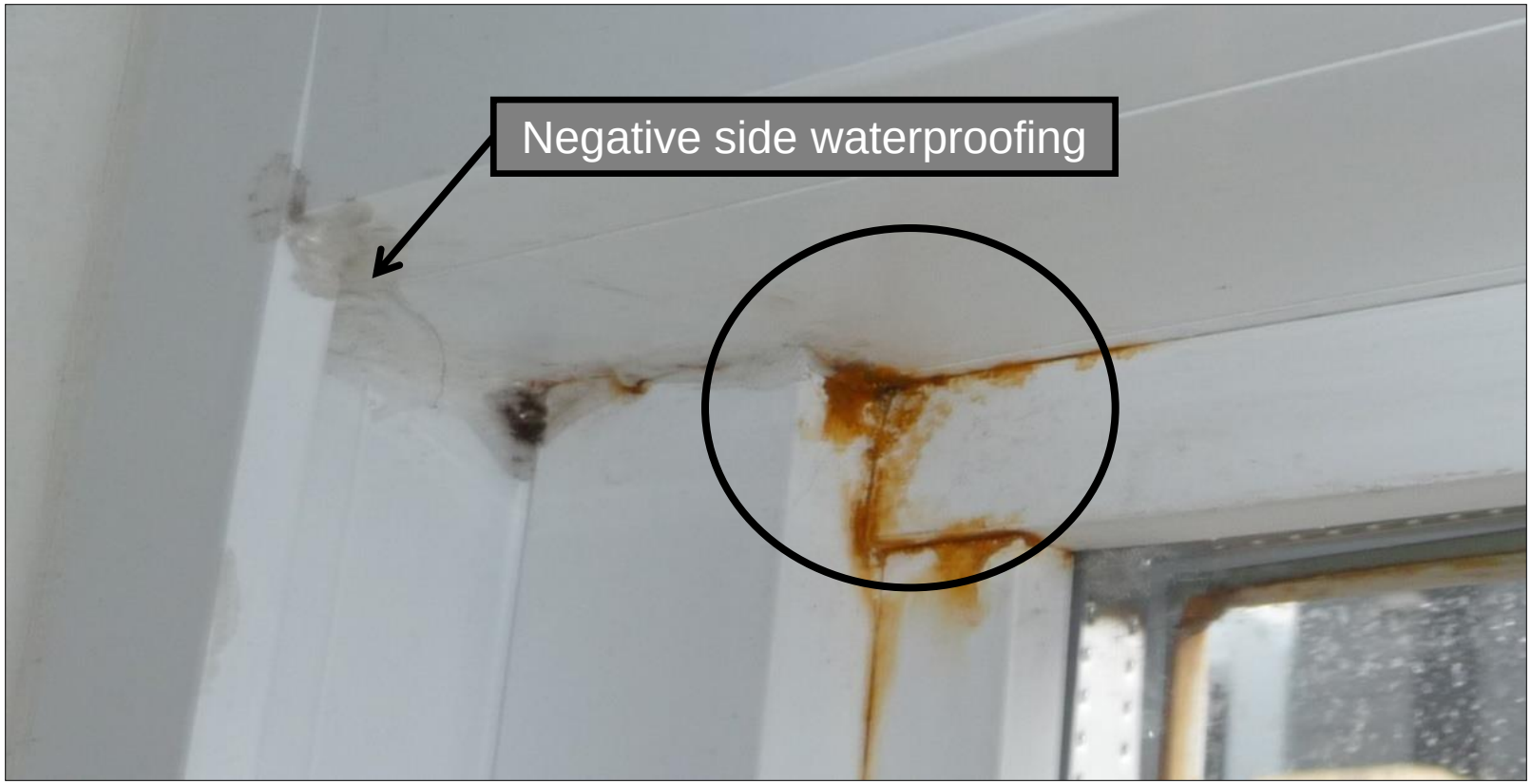
Improperly Constructed Weep And Drainage

- Windows were manufactured with improperly constructed weep holes and drainage pathway
- The weep holes were constructed with 5 mm (13/64”) diameter hole which encourages surface tension and prevents proper drainage down the pathway
- According to the Glazing Association of North America, the minimum size of weep hole to prevent surface tension is 8 mm or 5/16”

Drainage Pathway Analyzed



Rust Stain at Coped Joint From Reinforcing

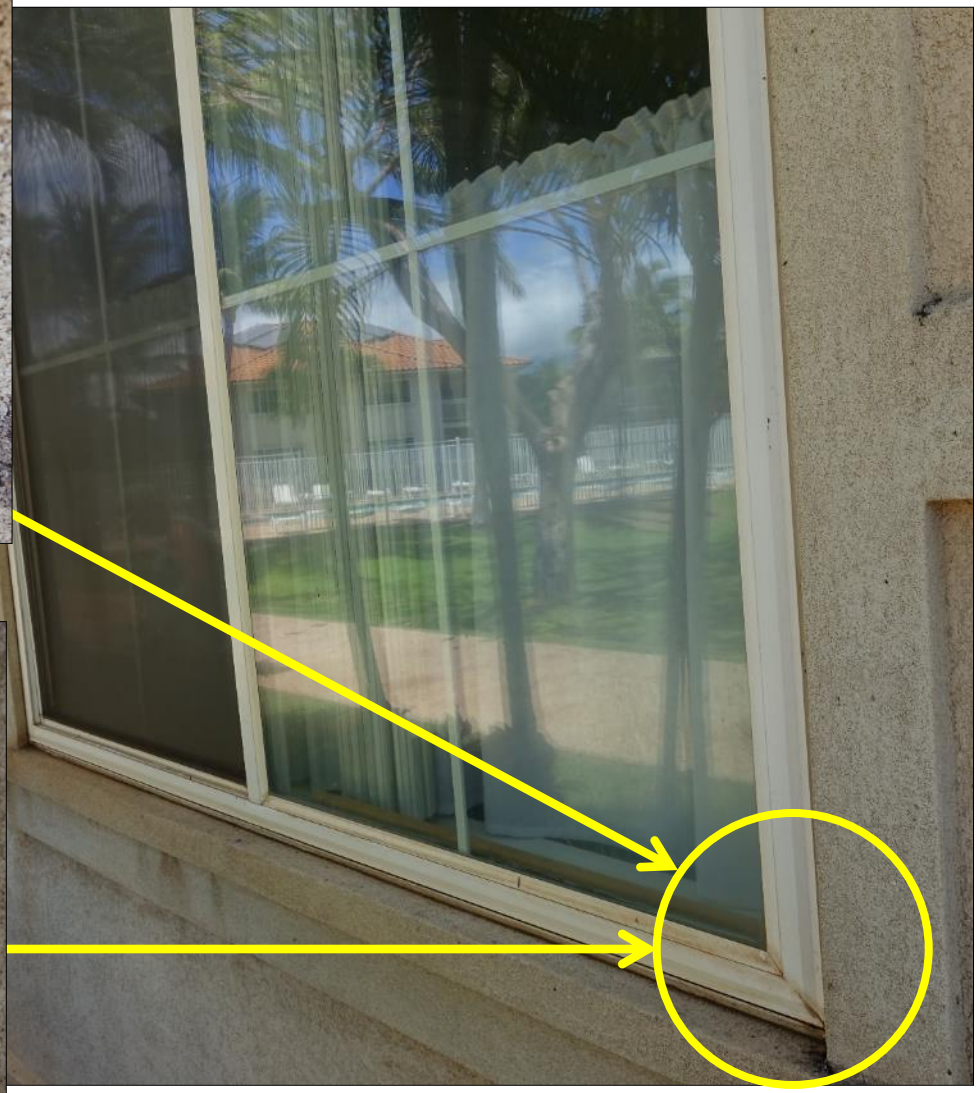


Sealant installed at underside of coped horizontal-to-vertical mullion joint failed to stop the leak. The leaks are rust staining from the structural steel reinforcement

Window Drainage and Weeping Issues

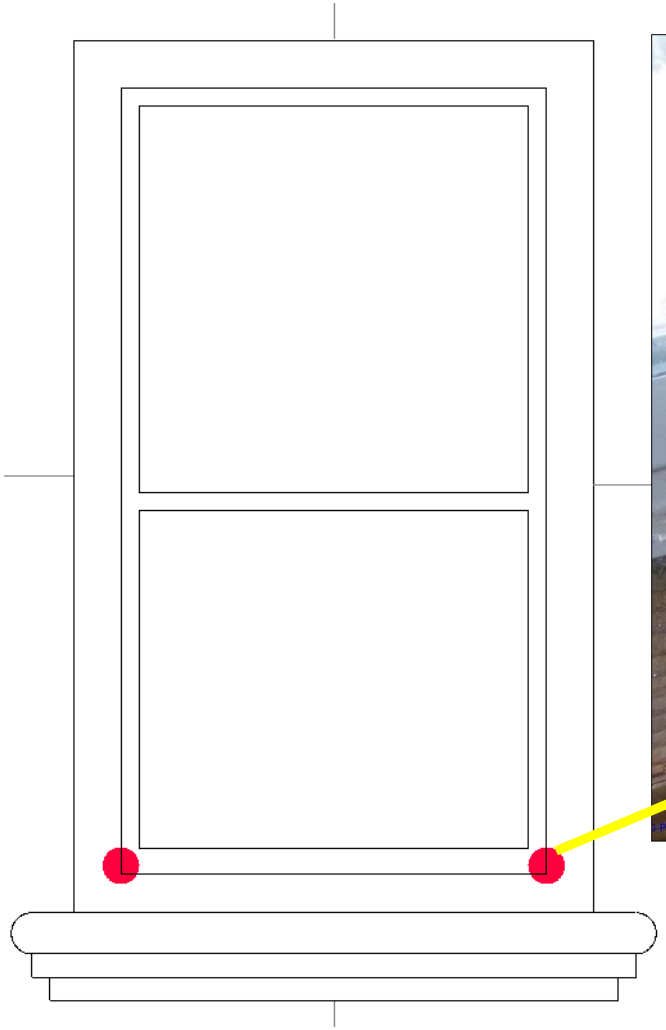
- Water traveling down weep pathway can rust the steel bar

Window Frame Corner Cracked and Leaking



Poor Quality PVC and Manufacturing

Aluminum Fin-Style Window Leaks at Corners



Window Frame Corner Seals and Leaks

- **Aluminum Frame Corners are sealed in the factory before being screwed together. Applying sealant in place from the top doesn't work because of lack of proper geometry and profile**

Sealant is applied in the frame corner joint before the frames are screw splined together

Leak at Coped Corners Due To Failed Sealants

Failed Corner Acrylic Sealants, Exposed to UV

According to recent laboratory testing, the acrylic sealants are inherently not designed for the window frames and can revert to a tacky state due to chemical degradation. These sealants are not recommended where water immersion will occur

Conclusion, Fin (Flange) Style Windows

- Aluminum and vinyl windows can prematurely fail within 10 years due to inherent flaws. Fin-style windows are capable of lasting 25-50 years if properly fabricated and installed
- Coped or mitered horizontal to vertical joints can fail if they are not properly designed and manufactured
- Glazing gaskets fail due to poor internal glazing, poor acrylic foam tape material, poor frame contact, lack of back-up sealant
- Mulled windows are very susceptible to failure
- IGU Seals are susceptible to failure if coatings are not edge deleted and proper types of IGU sealants are not used

Examples of Exterior Sealant Life Expectancy

Material Selection Example:

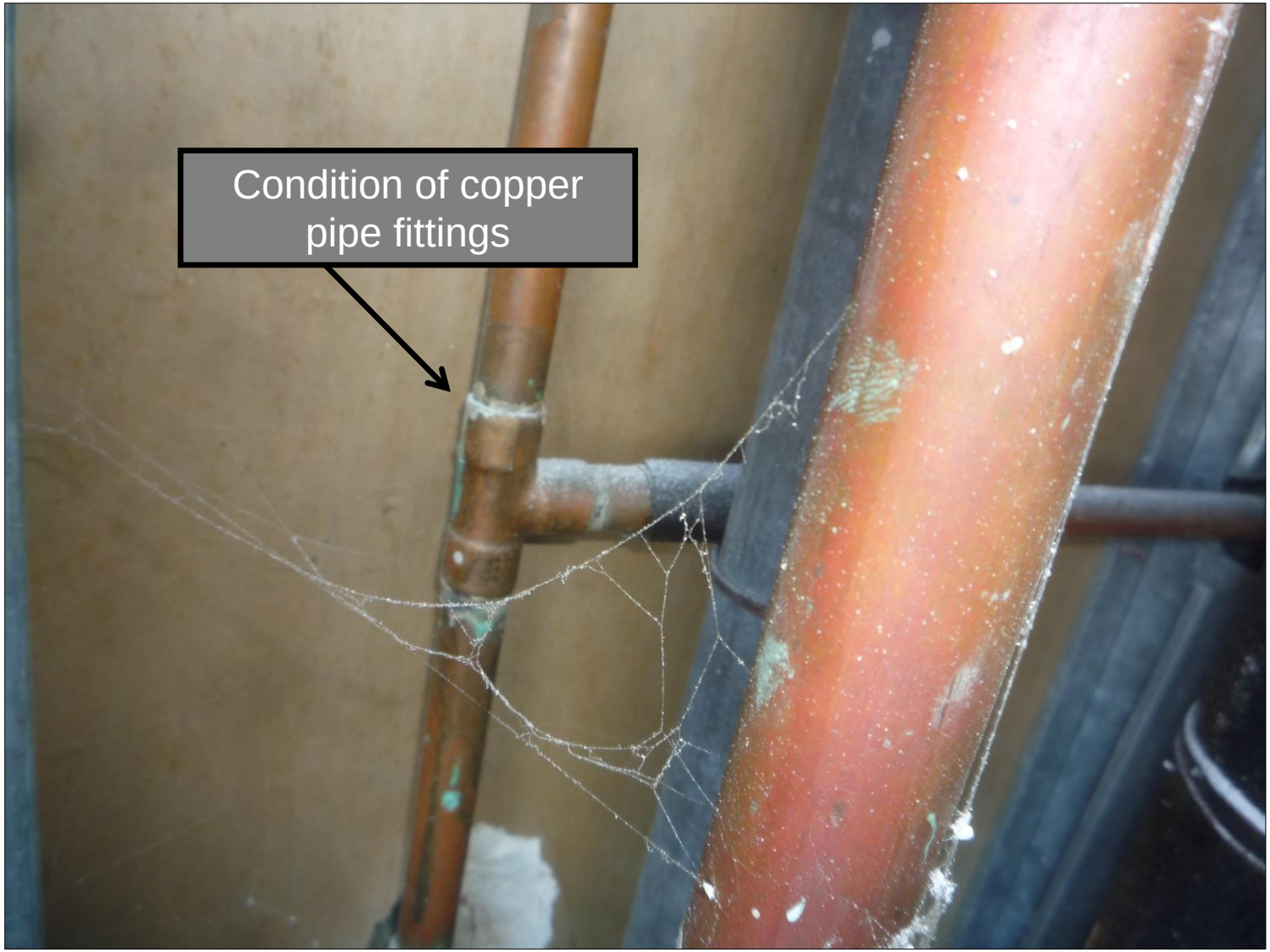
Polyurethane sealant prematurely failing after 7 years

Silicone sealant can last up to 40 years, only slightly more expensive

Life Expectancies of Plumbing Systems

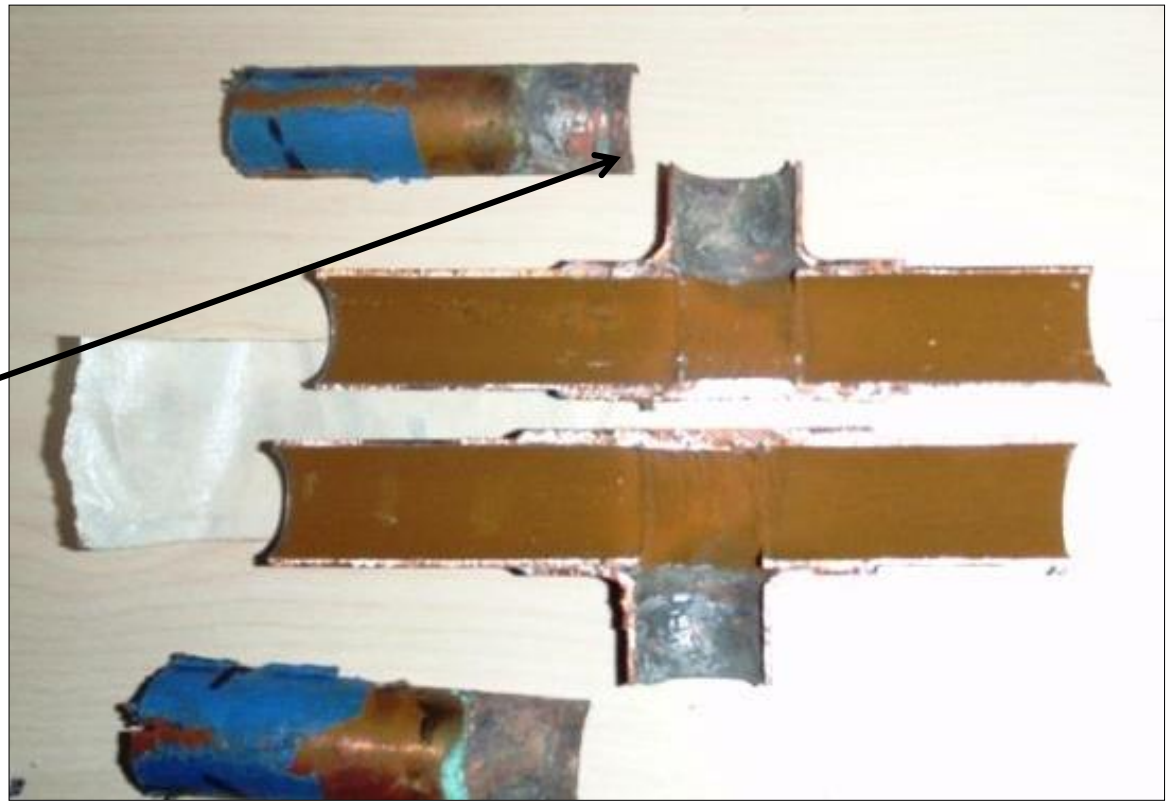
Is this a Plumbing or Electrical Problem?

Poor Workmanship



Poor Workmanship

Solder joints in 40 year old ½" copper pipe – fell apart at joints due to poor soldering.



Copper Pipe at 35 Years

Workmanship

- **Use only contractors with solid reputation**
  - Significantly low bids can be a cause for concern.
  - Unable to furnish a performance bond can be a cause for concern.
- **Specify hydrostatic pressure test of piping systems**
- **On copper systems require chlorination and certificates of lab testing**
- **Require construction oversight by consultant**

Result of Galvanic Corrosion

Avoid Galvanic Corrosion

- **Use Dielectric Unions when joining pipes of dissimilar metals. Some dissimilar metals like copper and galvanized metal are not compatible and rust prematurely**
- **Avoid contact between dissimilar metals**
  - Copper piping hangars for steel pupes
  - Copper piping and metal strapping
  - Copper piping and steel unitstrut

Aged Coupling Failure

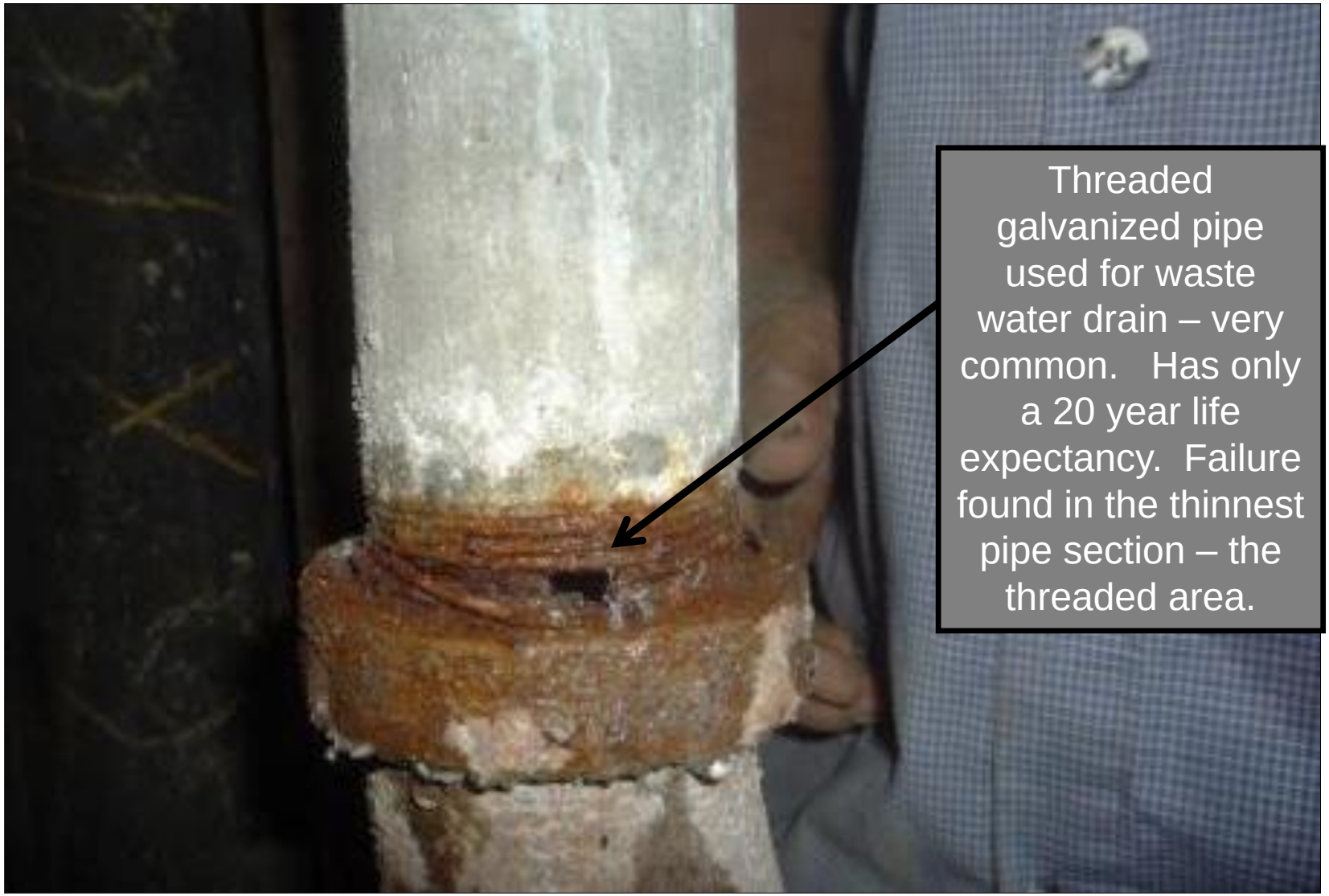
Pies and Gaskets at 35 years

Gasket Material Failure Due To Age

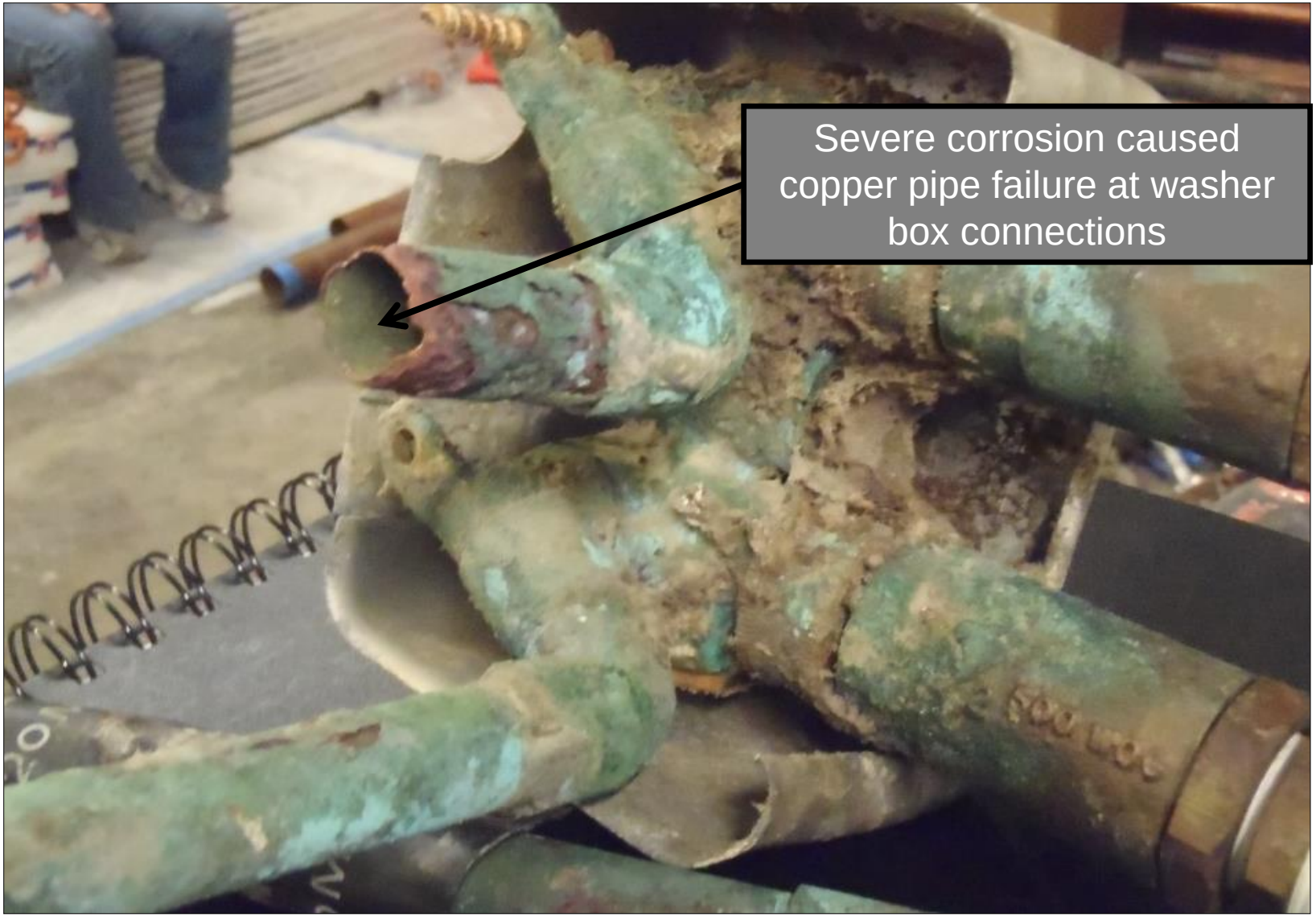
Aged Cast Iron Material Failure

Cast Iron Lasts 40-60 Years in Hawaii

Galvanized Pipes Last 20 Years in Hawaii



Accelerated Corrosion Due to Chemicals



Effects of Chemicals & Organic Compounds

Vent Pipe Failure Due to Rust

Maintenance of Plumbing Systems

- **Provide proper maintenance**
  - Hydrojet waste piping system mains on a regular basis – every 2 years minimum and higher frequency for kitchen and laundry waste pipes
  - Hydrojet vents through roof
  - Replace observed damaged couplings and gaskets
    - Usually observable failures in parking structures is a good indication of failure within the walls
  - Replace dielectric unions when replacing water heaters
  - Operate all service valves annually; replaced failed valves

Alternative Material Selection

- **Choose Materials Wisely**
  - PVC with Sound Jacket on Waste Pipe
    - Schedule 80 Below Grade
    - Schedule 40 Above Grade
  - PVC for Vent Pipe
  - Cast Iron Waste Pipe
    - Standard No Hub
    - Other Choices such as thicker pipes
    - Hub and Spigot – Class SV for Service
    - Hub and Spigot – Class XH for Extra Heavy
    - Glass for laboratory use

Pipe Lining

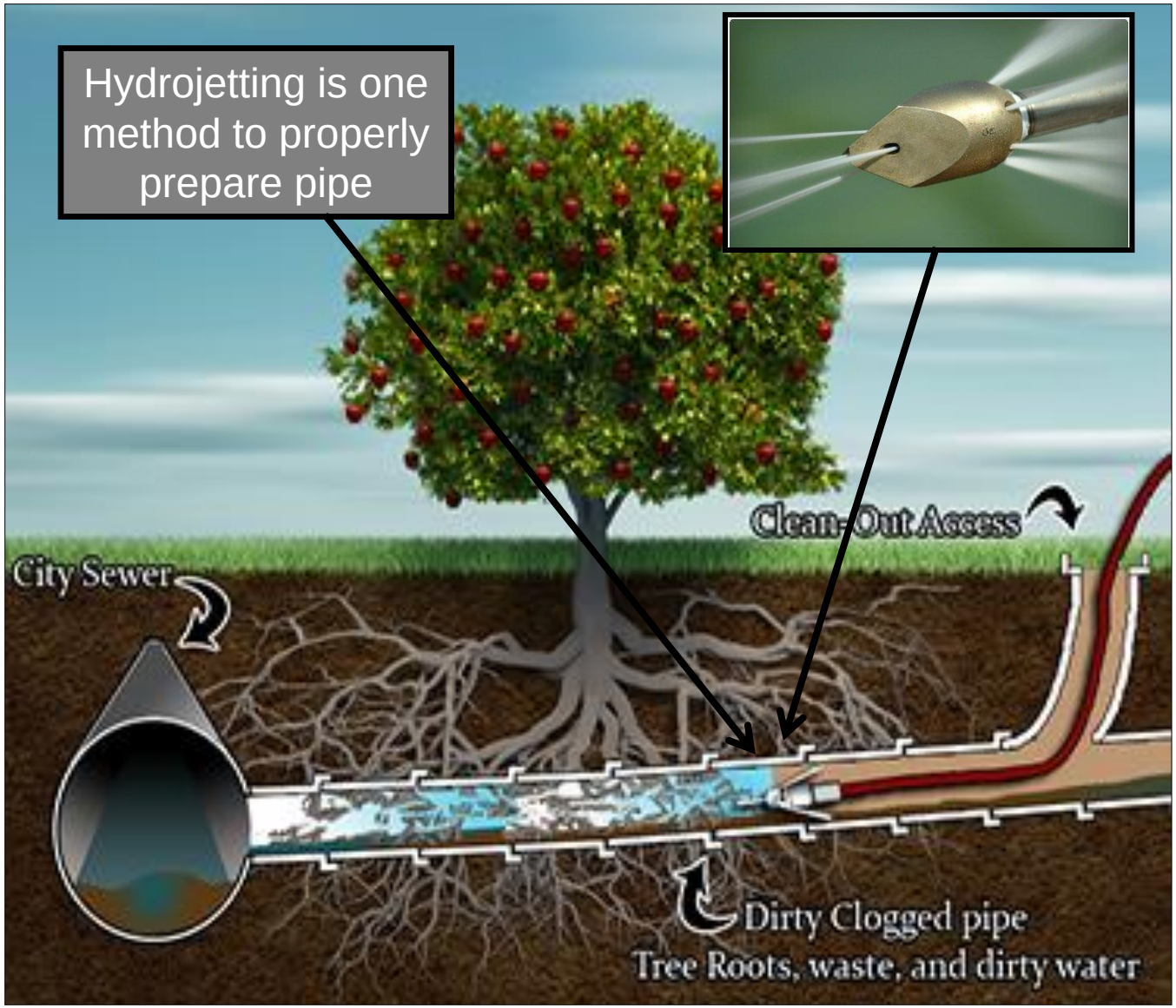
- **Pipe Lining is a specialized application to be used in conjunction with pipe replacement and not as a substitution for pipe replacement**
  - Pipelining use should be motivated by economically impractical project conditions such as pipe buried below occupied slabs, under adjacent buildings, or in concrete walls
  - Involves the insertion of a resin impregnated fabric tube into the existing cast iron pipe
  - Easily bridges cracks and missing sections of pipe wall
  - The hardened sleeve provides some level of structural integrity
  - Manufacturers report a life expectancy of 50 years

Pipe Lining – Below Grade Pipe To Be Lined

Pipe Lining – Usually Requires Pipe Removal

Pipe Lining – Inspect The Pipe To Be Lined

Pipe Lining – Pipe Prep is Key



Pipe Lining – Calibration Tube Inserted

Pipe Lining – Sleeve Material

Pipe Lining – Filling Sleeve with Resin

Pipe Lining – Calibrating Resin Volume

Pipe Lining – Air Gun

Pipe Lining – Liner and Calibration Tube

Pipe Lining – Curing of the Pipe Lining

Life Expectancies of Anodized Aluminum Railings and Window Frames

Anodizing Aluminum

- **Choose Materials Wisely**
  - Anodized Coatings
    - Anodization is an electrochemical process which accelerates oxidization of the aluminum and enhances the color into a hard finish.
    - Comply with Aluminum Anodizers Counsel (ACC) Type II Class 1
      - Anodizing penetrates metal a minimum of 7 Mils
    - Tempered Aluminum Alloy 6063-T6
    - Anodized color will change between manufacturers; always request a sample

Anodizing Aluminum

- **Architectural Class I and Class II Anodize**
  - Class I and Class II anodic coatings are designations created by the Aluminum Association for the purpose of codifying the specification of anodized aluminum.
  - Class I coating has a mil thickness of 0.7 (18 microns) or greater
  - Class II coating has a minimum mil thickness of 0.4 (10 microns)
  - Class I coating is a high performance anodic finish used primarily for exterior building products and other products that must withstand continuous outdoor exposure.
  - Class II coating is a commercial anodic finish recommended for interior applications or light exterior applications receiving regularly scheduled cleaning and maintenance such as storefronts.
  - Coating thickness can be measured by an "eddy current", a nondestructive test instrument, or by cutting a cross-section of the anodized aluminum, mounting it in a slide, polishing the edge, and reading the coating thickness directly with a microscope.

Anodizing Aluminum

- Class I and Class II coatings should not be confused with Type I, Type II, and Type III anodic coatings as described in the authoritative anodizing standard, MIL-A-8625. Type I anodize refers to chromic acid anodizing. Type II is normal "clear" sulfuric acid anodizing. Type III is "hardcoat" using sulfuric acid or mixed chemistry electrolytes.
- All Linetec anodize finishes are a Class I coating, with the exception of ANO-204 Clear, which is a Class II coating. Clear anodize is available in both Class I and Class II. Class I anodize coatings are the only finishes that carry a warranty.

Anodize Overview - Linetec http://linetec.com/ANODIZE/Anodize_Overview.html

New Anodized Aluminum Window

Failure of Anodized Aluminum Window Frames

Failure of Anodized Aluminum

Corroding Anodized Aluminum Window

Choose Materials Wisely

- **Coating Railing Systems**
  - Beware of manufacturer warranty with disclaimers regarding proximity to ocean
  - Use American Architectural Manufacturers Association (AMMA) 2605
    - AMMA 2605-05 10 Year color retention and chalk resistance
      - Polyvinlidene Flouride (PVDF) Resin
      - Coating must be at least 70% PVFD
      - Coating thickness a minimum of 30 microns (1.2 mils)
    - AMMA 2604-05 5 Year color retention and chalk resistance
      - Silcon polyester coatings
      - Coating thickness a minimum of 30 microns (1.2 mils)
    - AMMA 2603-02 1 Year color retention and chalk resistance
      - Applies to polyester and acrylic coting intended for interior use
      - A minimum of 20 microns thickness (0.8 mils)
  - Powder coatings provide 10 to 15 year life
    - Some manufacturers provide 60 plus microns of coating.

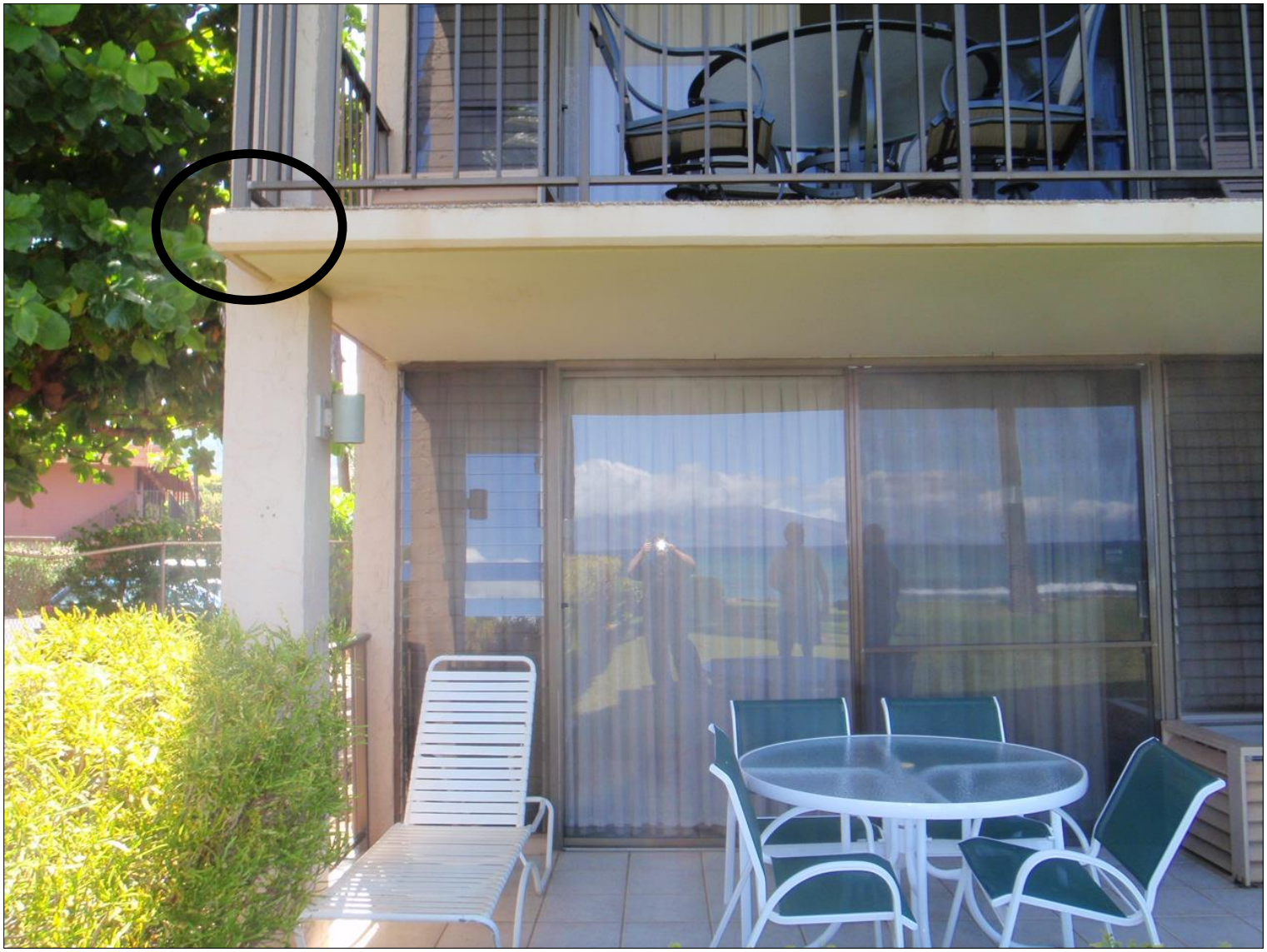
How Is This Repair Working?

Hand Rail Galvanic Corrosion (Dissimilar Metals)

Galvanic Corrosion (Fastener Not Compatible)

Galvanic Corrosion (Dissimilar Fastener Metal)

Aluminum Railings and Concrete Spalling



Post In Direct Contact With Concrete Rebar

Proper Assembly Techniques

- **Avoid contact between dissimilar metals**
  - Stainless Steel fasteners coated with a MAGNI 555 Coating

    Magni 555 is a duplex fastener coating system that combines an inorganic zinc-rich basecoat with an aluminum-rich organic topcoat. The basecoat provides sacrificial protection of the steel substrate while the topcoat creates a durable barrier. Magni 555 is engineered with integrated friction modifiers to eliminate the need for sealers or post coating lubricants. This feature ensures repeatable torque/tension characteristics in assembly. Magni 555 provides superior product performance in fewer layers than comparable finishes. Fewer processing steps results in improved quality and reduced costs. Magni 555 is designer for use on fasteners such as nuts, bolts and other miscellaneous hardware. Magni 555 can be applied via dip/spin, dip/drain, or spray application methods.

    Magni 555 Product Description- Sun Belt Coating, LLC http://sunbeltcoating.com/
  - Steel L Brackets are not a recommended repair
- **Provide proper installation**
  - Rail post ends need to be coated with epoxy before setting in grout
  - Fill rail posts with self leveling low modulus poly urethane sealant using drill and fill practice. This will reduce spalling at rail post pockets by preventing water migration into concrete.

Life Expectancies of Horizontal Assemblies

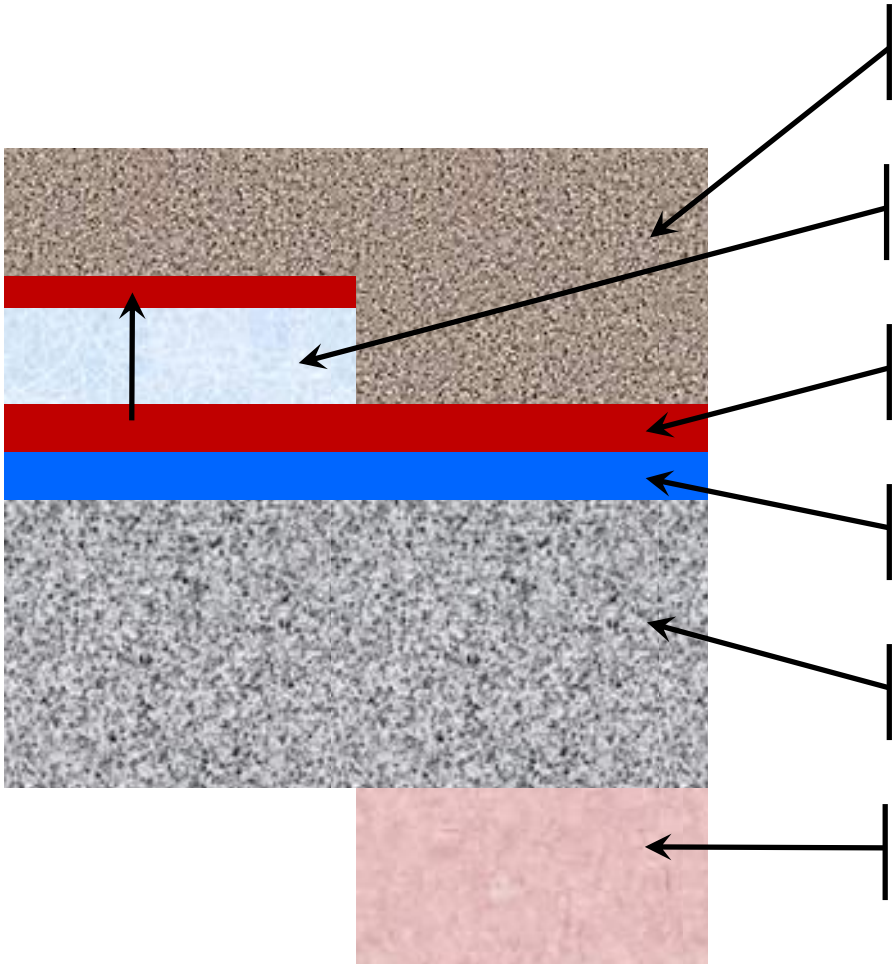
Life Expectancies of Horizontal Waterproofing

- **Trafficable Waterproofing Systems:**
  - Polyurethane Deck Coatings (10 – 20 years with 4-5 year recoat)
  - Poly Methyl Methacrylate (PMMA 20-40 Years with 10-20 year recoat)
  - Acrylic Deck Coatings (5-10 years with 3-5 year recoat cycle)
  - Lath reinforced Polymer Modified Cement based systems (10 to 20 years with recoat every 3-5 years)

- **Concealed & Protected Systems:**

  (Overburden with concrete topping, pavers, planters, etc.)
  - Reinforced Hot Rubberized Asphalt (50+ years)
  - Modified Bitumen (50+ Years)
  - Single ply membranes (50+ years)

Split Slab, Protects Waterproofing From UV & Traffic



Concrete traffic surface

External insulation (optional)

Protection and drainage

Waterproofing membrane

Structural deck

Internal insulation (optional)

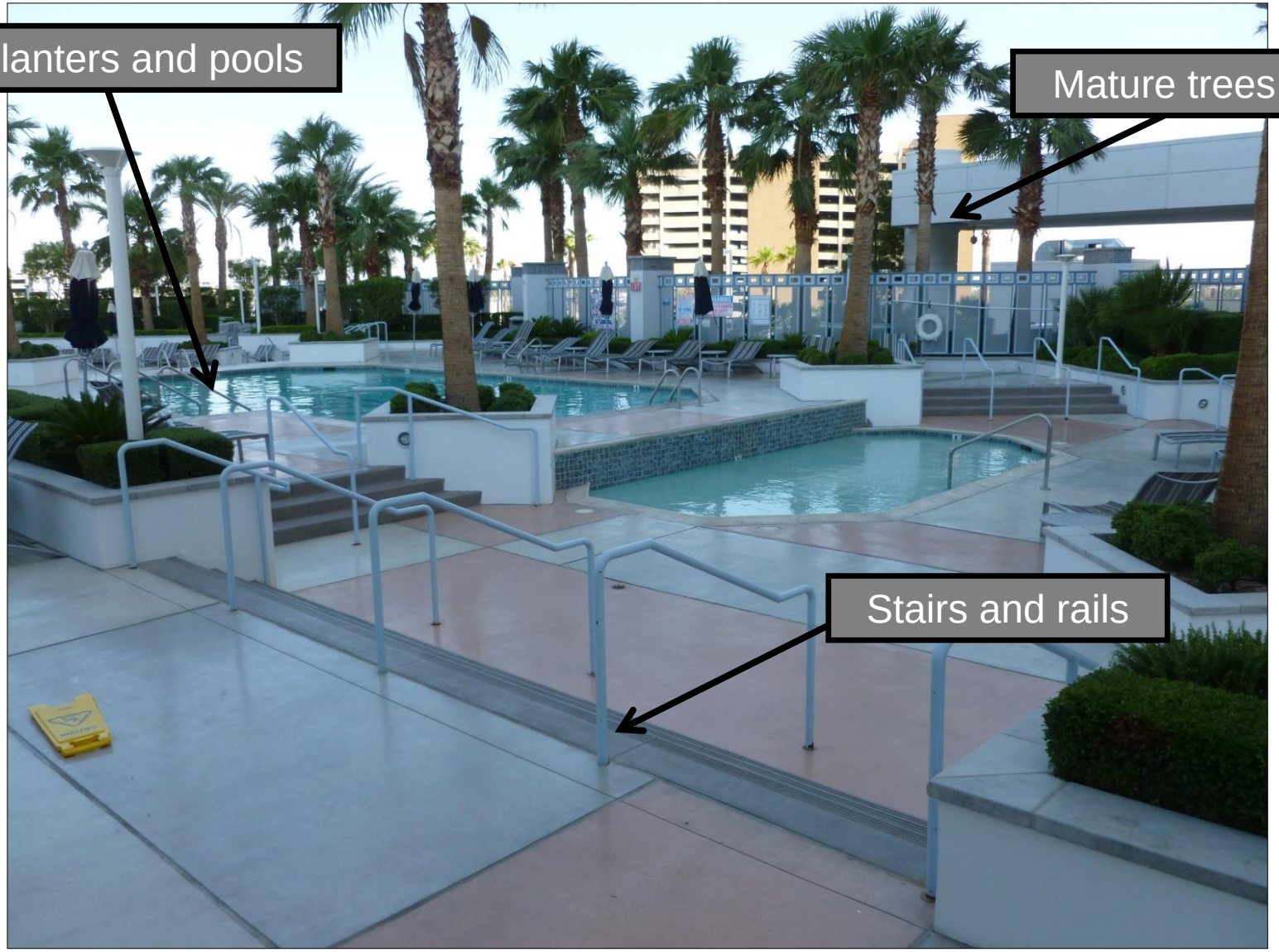
Life Expectancies, Protected Assemblies

Life of the building – Typically 50+ years

Why Protected Assemblies Are Built For Life?

- **Can have very expensive and elaborate over-burden such as planters, trees, play equipment, pools, gazebos, etc.**
- **Integrated with exterior façade (walls) and entrance doors, storefronts, curtain wall, etc.**
- **Protected from UV and heat**
- **Protected from foot traffic and vehicular traffic**
- **High Replacement Cost:**
  - While waterproofing membrane can cost less than $10/foot, total repair cost can exceed $150/SF!
- **Major disruption to occupied buildings**
- **Loss of use – Abatement of rent or lease**

Post Tensioned Concrete Pool Decks



Why Protected Assemblies Are Built For Life?

These assemblies require extensive integration with permanent features

Complexities and Repair Cost of Podiums

Elevated Exterior Surfaces on Wood Framing

These assemblies require extensive integration with permanent features

Wood Decks – w/Concrete Walkways Surfaces

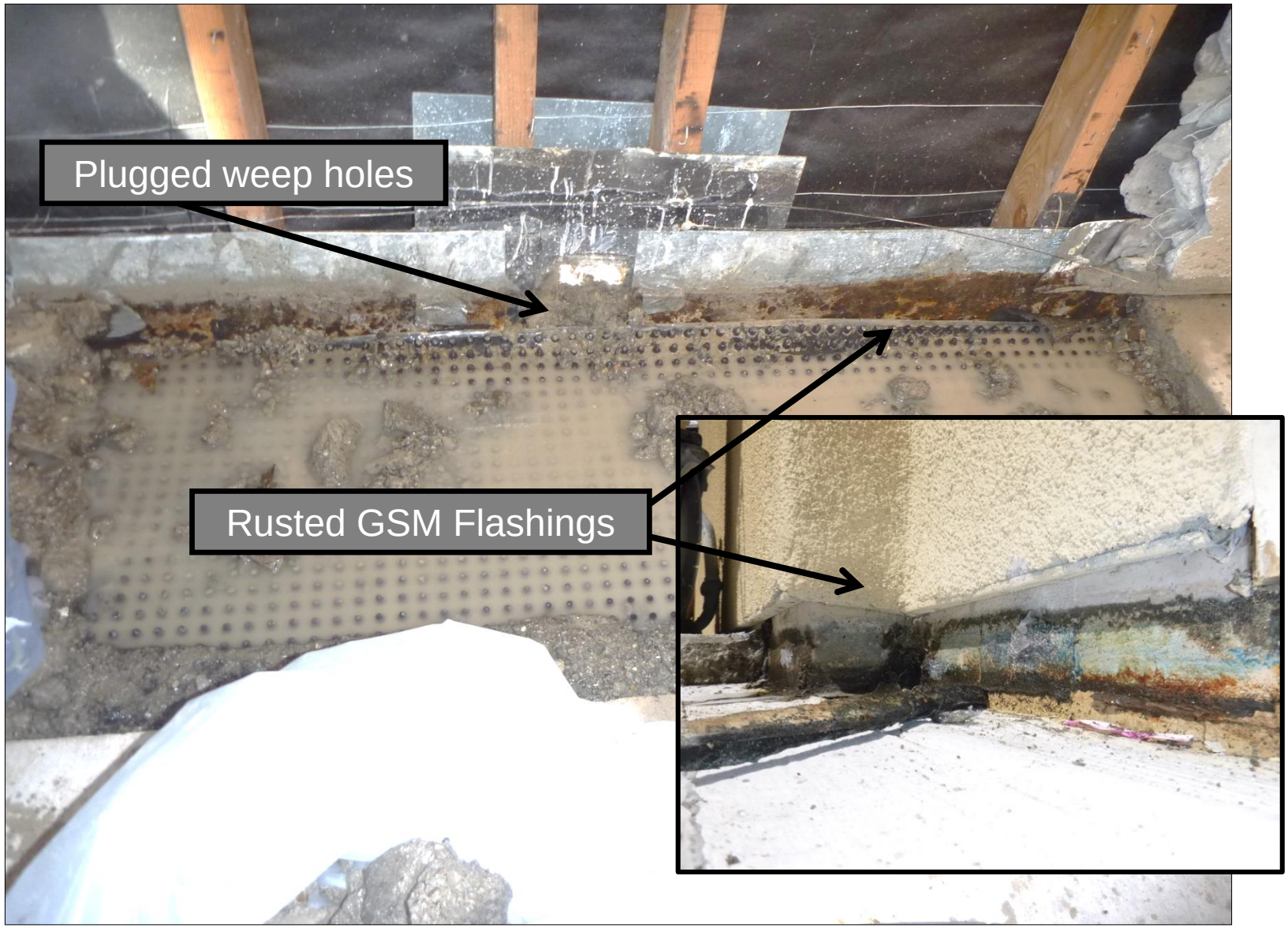
Complexities of Repairing Wood Walkways

Common Failure Mode In Horizontal Waterproofing

- Improper design and installation of flashings
- Use of unproven waterproofing materials
- Improper drainage pathways and slope
- Lack of surface preparation and primers

Lack of Soldering Saddles, Corners & Scuppers

Rusting of Submerged GSM Flashings

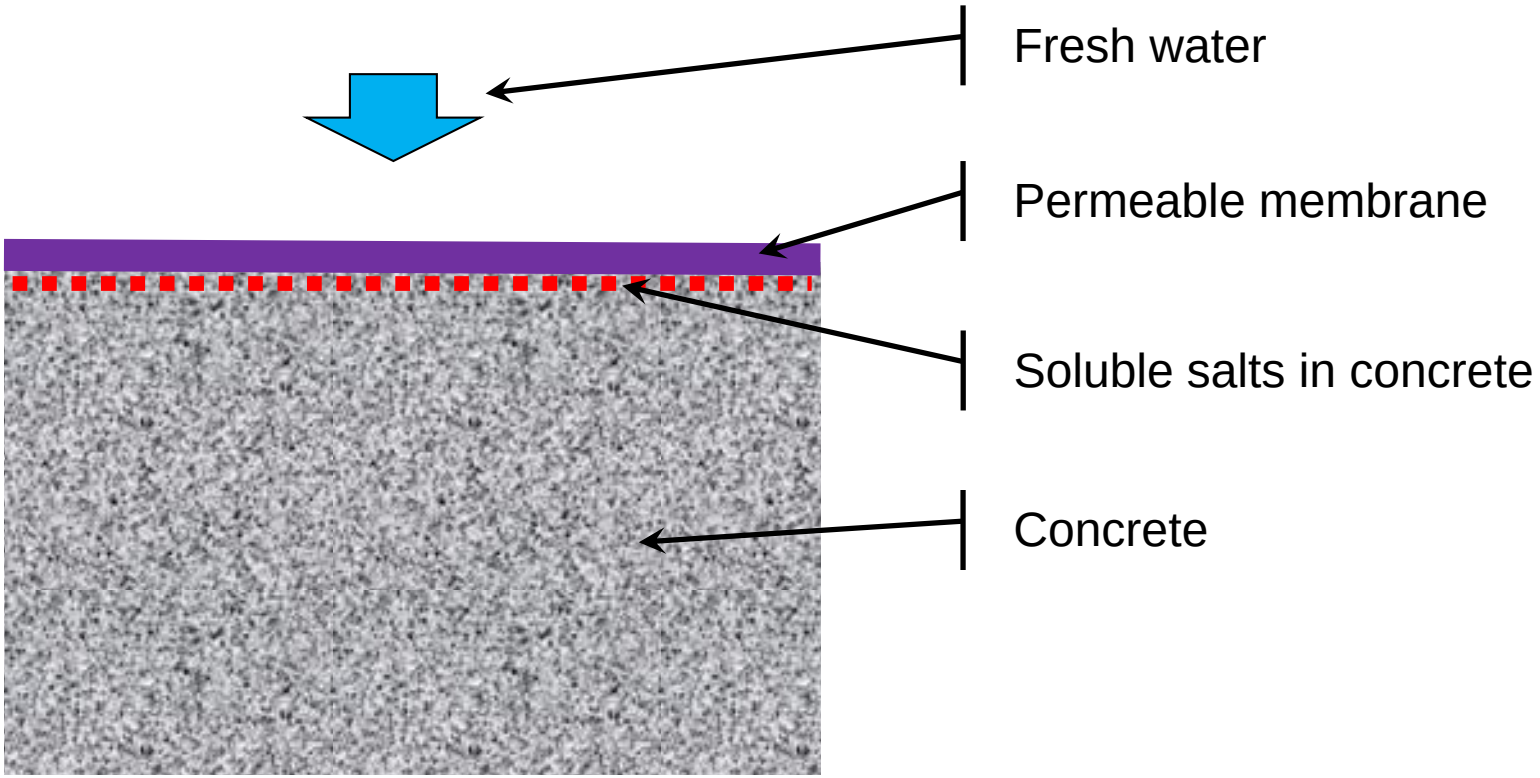


Improper Selection of Materials

- **Cold modified polyurethane waterproofing membrane**
  - Osmosis in Permeable Membranes

Semi-Permeable Membranes, Osmosis

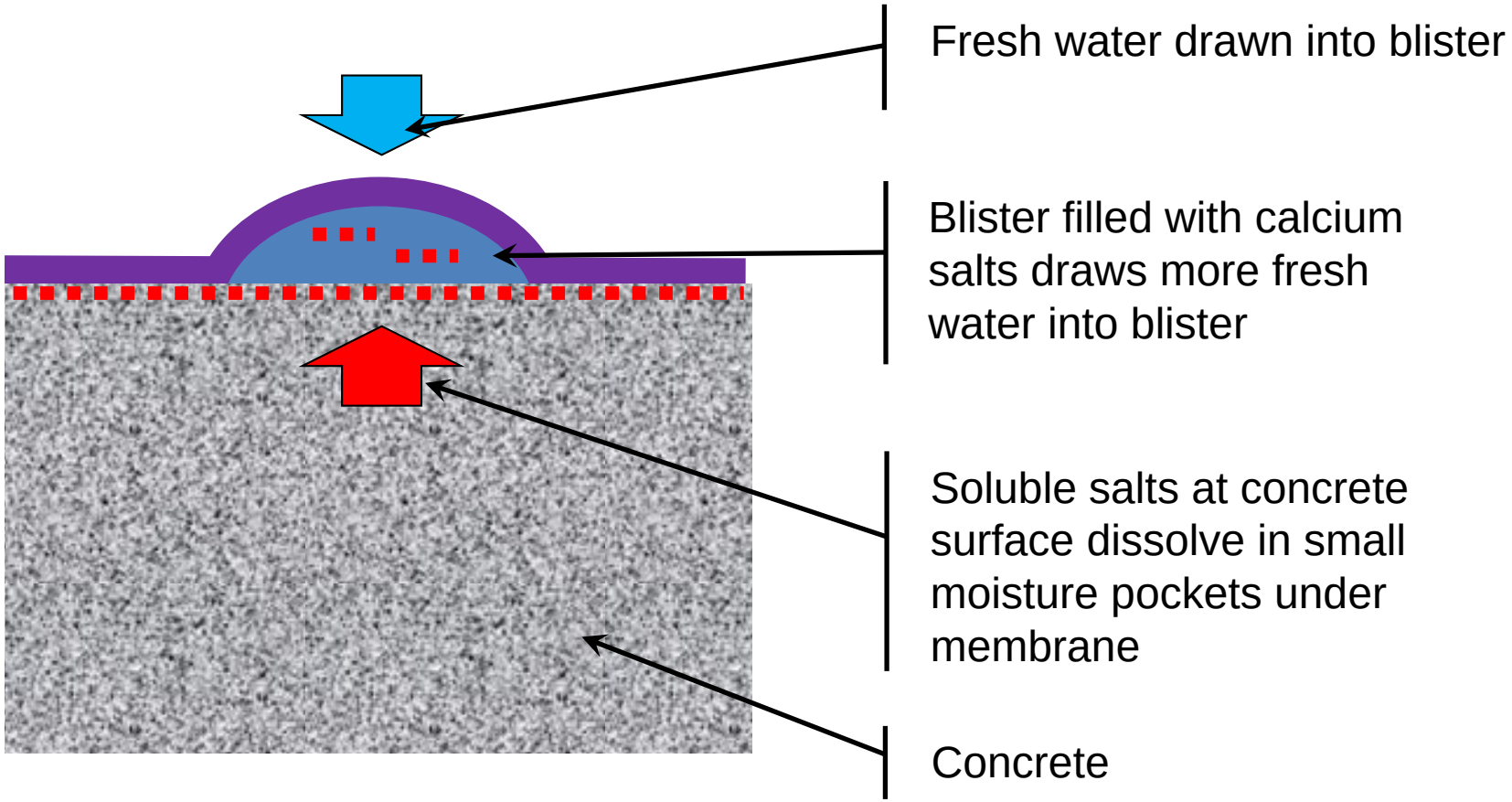
- **Cold Systems**
  - Osmosis and Permeable Membranes



Semi-Permeable Membranes, Osmosis

Cold Systems

– Osmosis and Permeable Membranes



Membrane Permeability Rusting GSM

Permeability Issue, Rusting GSM Flashings

Membrane Swelling Due To Ponding

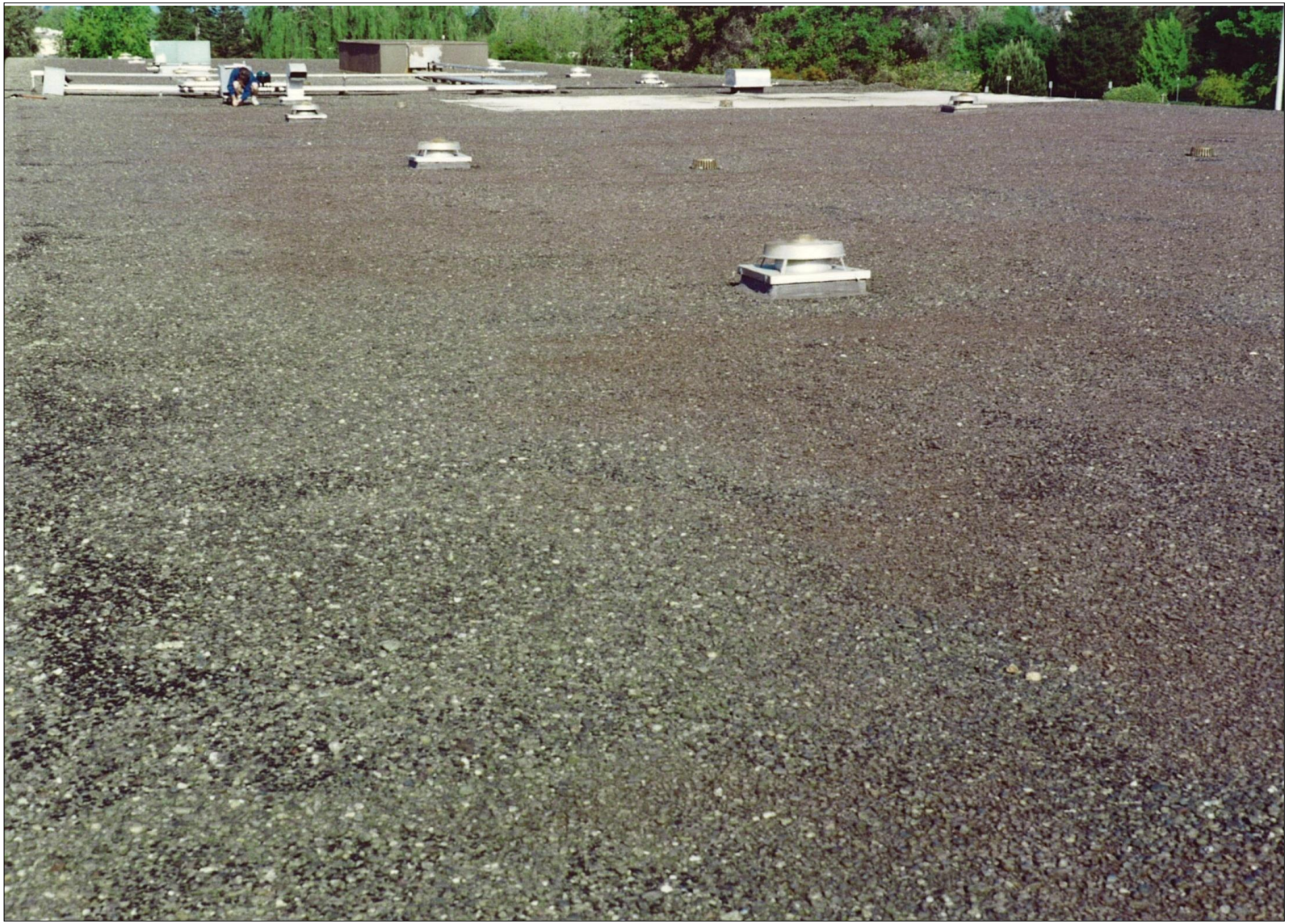
Key Elements of WP Assemblies Built for Life

- **Selection of appropriate waterproofing membrane**
  - Deal with standing water
  - Flashing and integration with doors and façade
  - Permeability of membrane (Friend or foe?)
- **Selection of Flashings:**
  - Stainless steel or copper, as opposed to Galvanized
  - If Galvanized, protect further with waterproofing
  - Composition base flashings
  - Neoprene
- **Proper drainage**
  - Surface drainage
  - Sub-surface drainage
- **Proper protection:**
  - Construction traffic damage
  - Trees and roots
  - Freeze/thaw
  - UV damage during construction

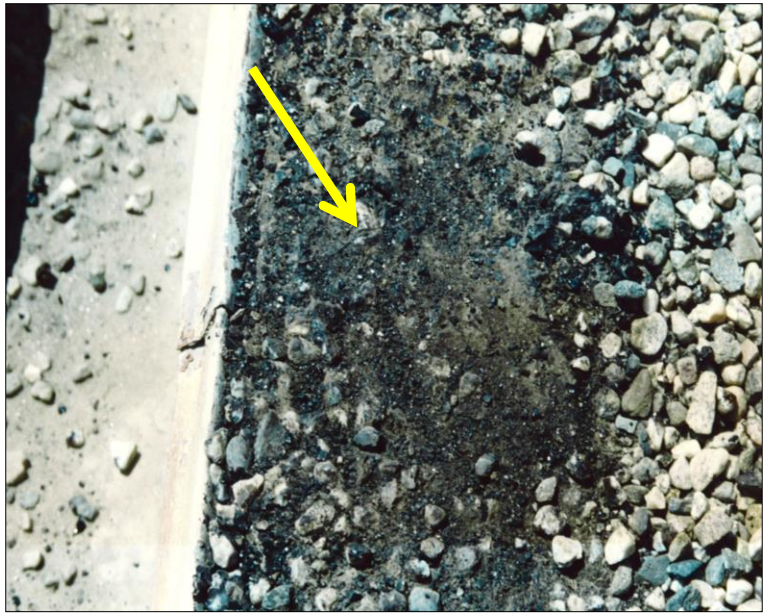
Commercial Roof Life Expectancies

- **Roofs are capable of lasting 40+ years but most don't**
- **Some single ply roofs are newer on the market and don't have proven performance track record**
- **Roofs can get damage and fail due to excessive foot traffic**
- **Roofs can fail due to environmental conditions**
- **Roofs can fail due to improper installation of components**
  - System attachment issues
  - Flashings issues
  - Contamination issues
  - Design issues
  - Slope issues

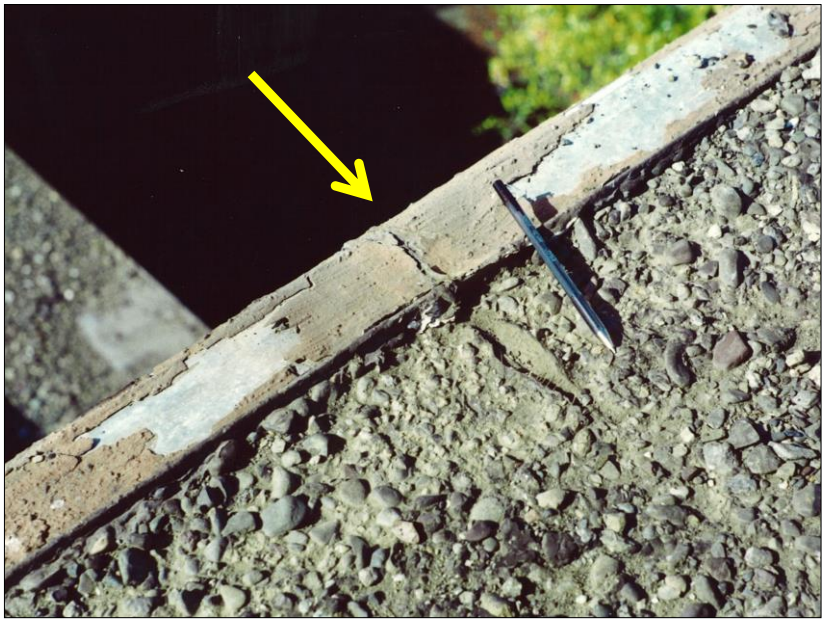
Example Of a 34 Years Old Performing Roof



How Good Workmanship Made The Difference



- Gravel stop joint is performing well after 34 years
- Roof could last 40-50 years
- Gravel embedment is excellent, providing great UV resistance and protection from traffic



- Gravel stop joint is splitting after 20+ year old roof
- Gravel embedment is fair
- Life expectancy 25+ years with ongoing repairs and maintenance

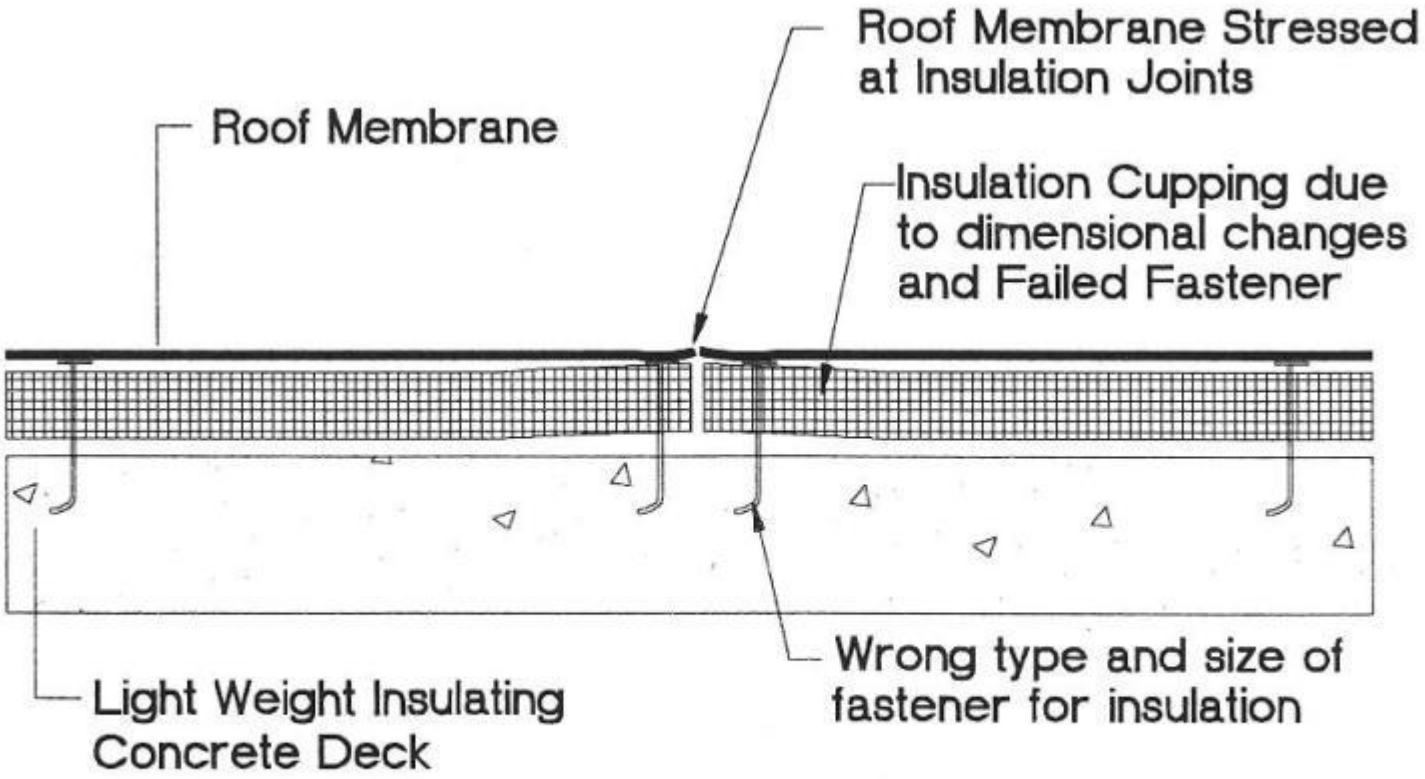
Ponding Water Leads to Premature Deterioration

Premature Roof Failure, Improper Attachment

A very expensive roof at a major west coast university, failing after only five years. Installation by large company, roofing manufacturer 20 year warranty

Cause of Failure: Improper Insulation Fastening

Improper Attachment Caused The Roof Failure



PICTURE FRAMING + ROOF SPLITTING CAUSED BY POOR FASTENING OF INSULATION BOARD TO SUBSTRATE

PVC Case Study: Department Store

PVC Case Study: Department Store

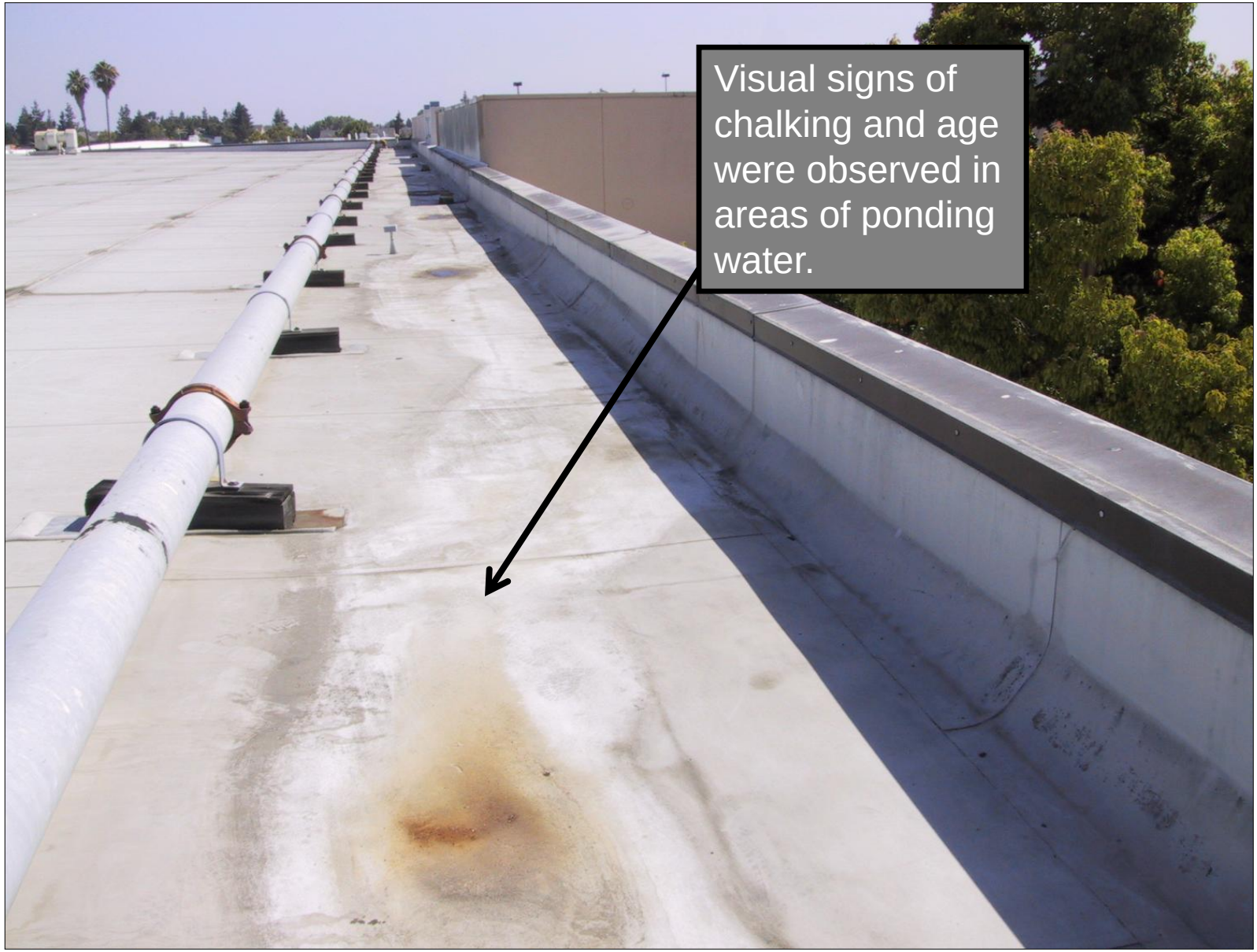
Design Issue

Single Ply Membranes Very Susceptible To Damage

Single Ply Membranes Very Susceptible To Damage

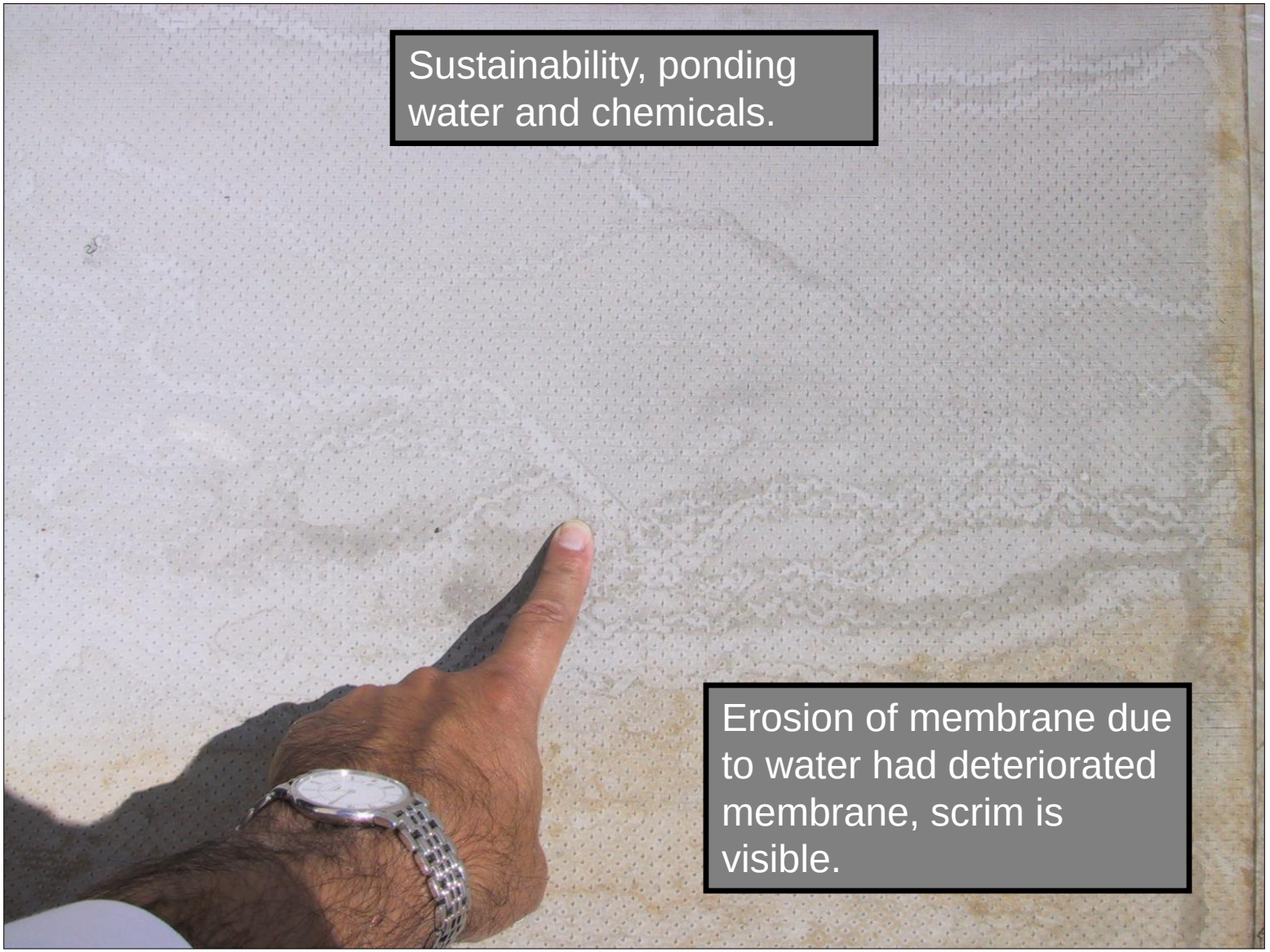
Single Ply Membranes Very Susceptible To Damage

Single Ply Susceptible To Standing Water



Single Ply Susceptible To Standing Water

Single Ply Susceptible To Standing Water



PVC Roof Membrane Sustainability Score

- **Membrane Material**
  - Field areas of membrane performance good 20+ years for 40 mil membrane
  - 80 Mil membrane may last 30+ years
  - Easy to patch on back of sheet. Did not attempt to patch on front of sheet

- **Traffic And Impact Damage**
  - Susceptible from impact damage
  - Damage easy to identify and repair

Poor Design Degrading Sustainability

- **Design**
  - Original poor design of pipe supports caused damage
  - Poor design of roof drainage caused ponding water and damage. Membrane susceptible to ponding water
  - Poor design of condensation control mechanism caused damage

ALLANA BUICK & BERS

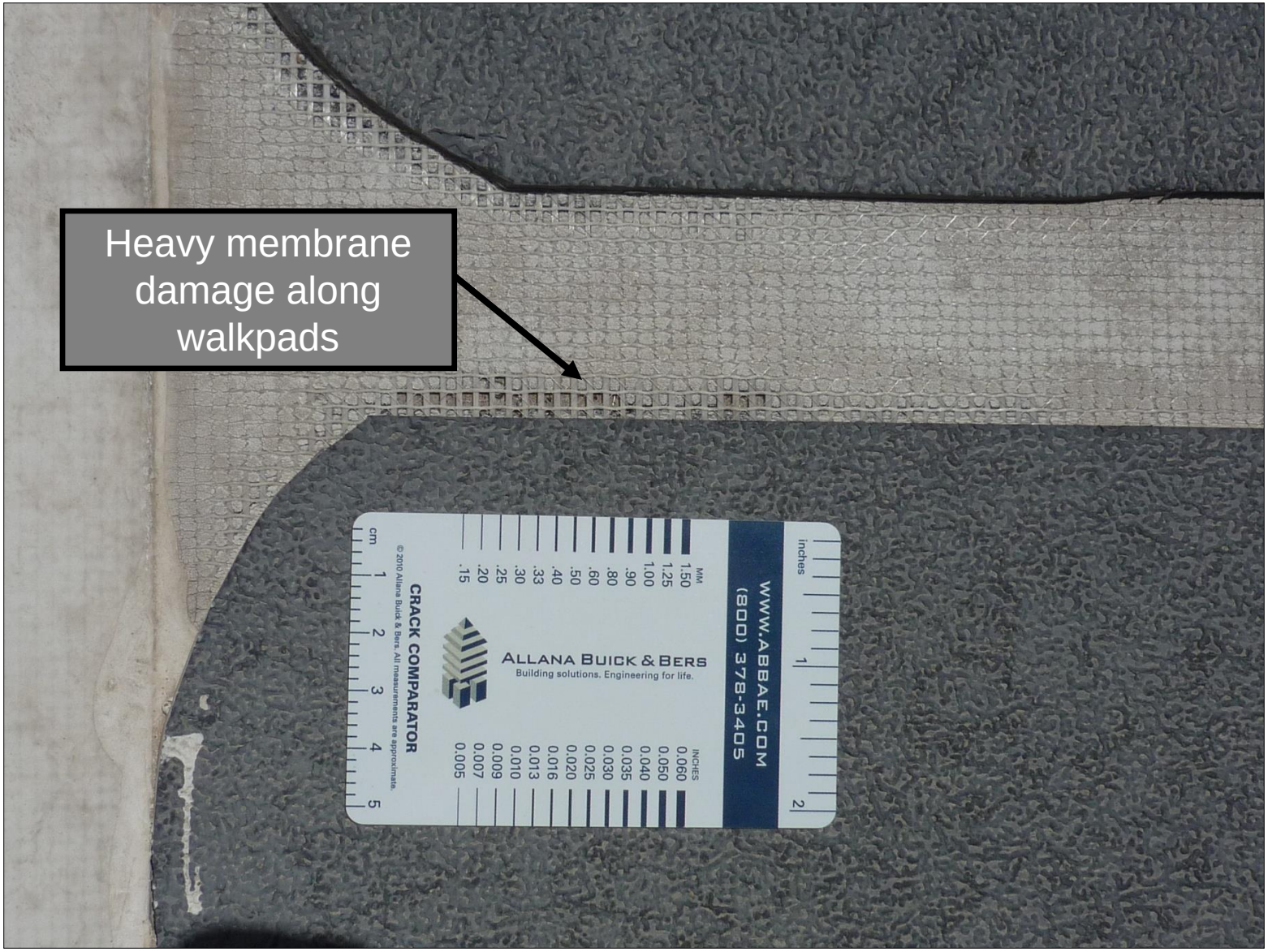
Making Buildings
Perform Better

TPO Roofs and Performance

Study conducted in Las Vegas, Nevada

7 Years Old, Large Warehouse in Las Vegas

7 Years Old, Large Warehouse in Las Vegas

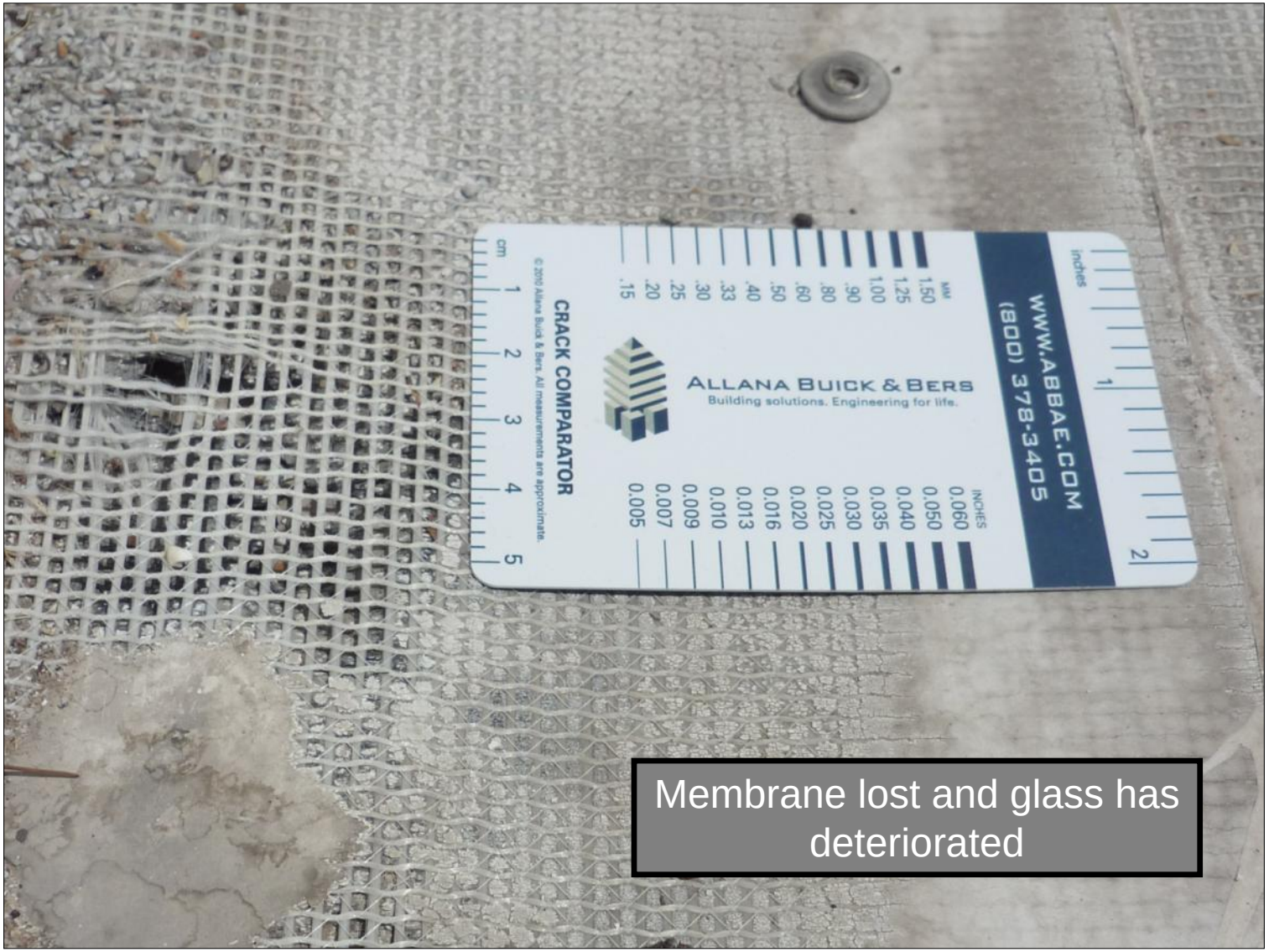


Large Warehouse in Las Vegas, Nevada

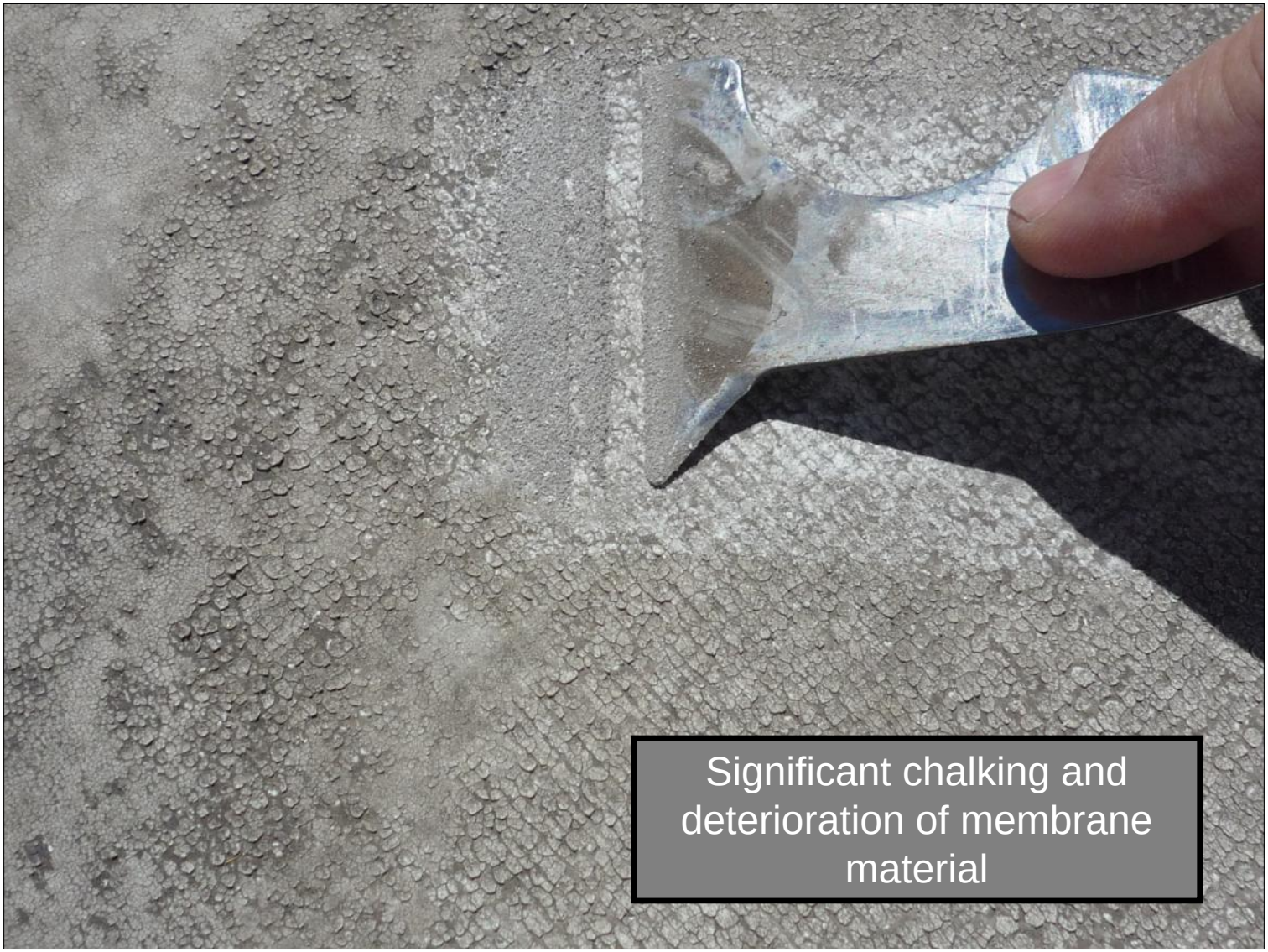
5 Years Old Carlisle, Hospital Building, Vegas

5 Years Old Carlisle, Hospital Building, Vegas

5 Years Old Carlisle, Hospital Building, Vegas

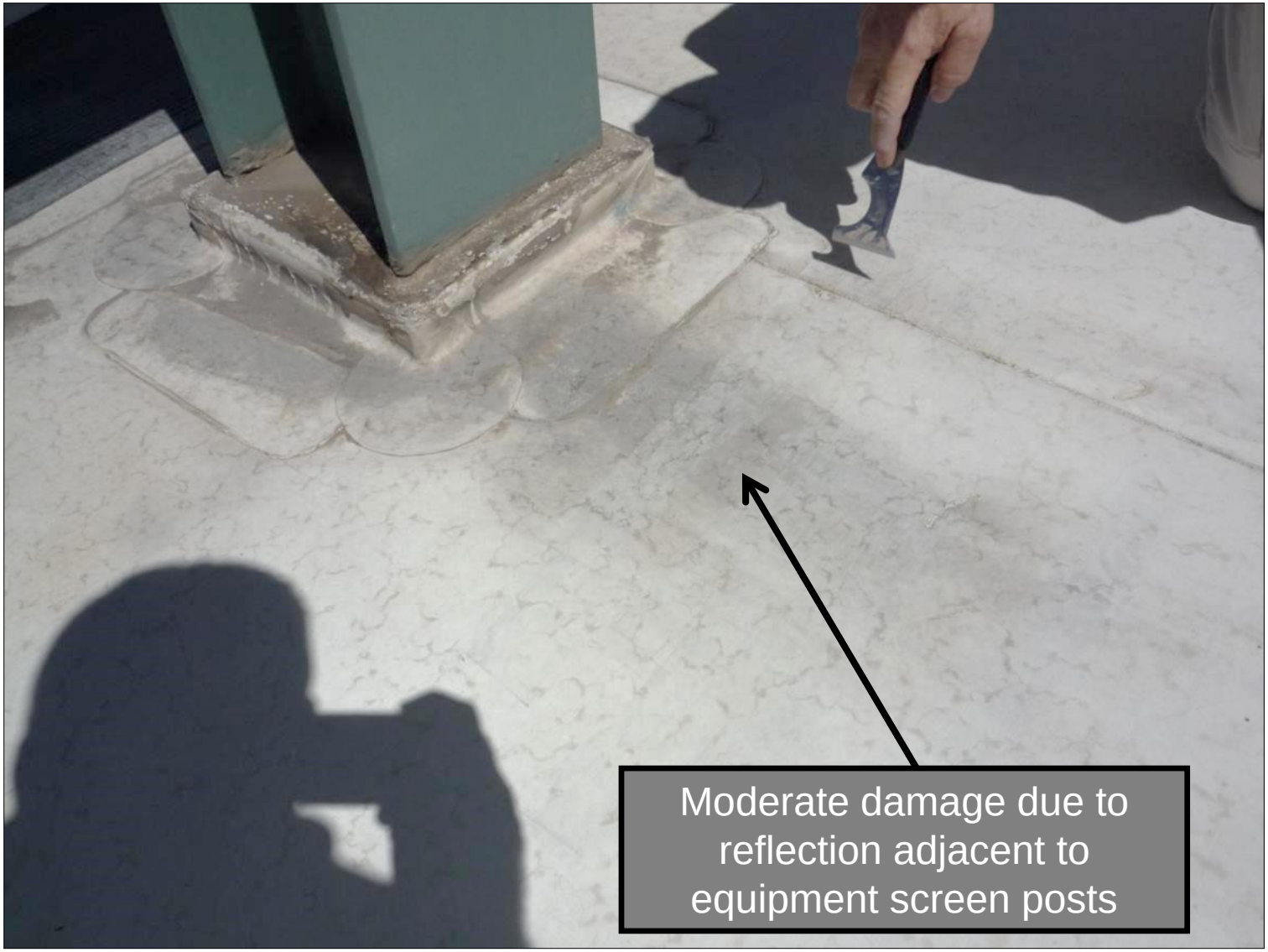


5 Years Old Carlisle, Hospital Building, Vegas



7 Years Old Carlisle, Hospital Building, Vegas

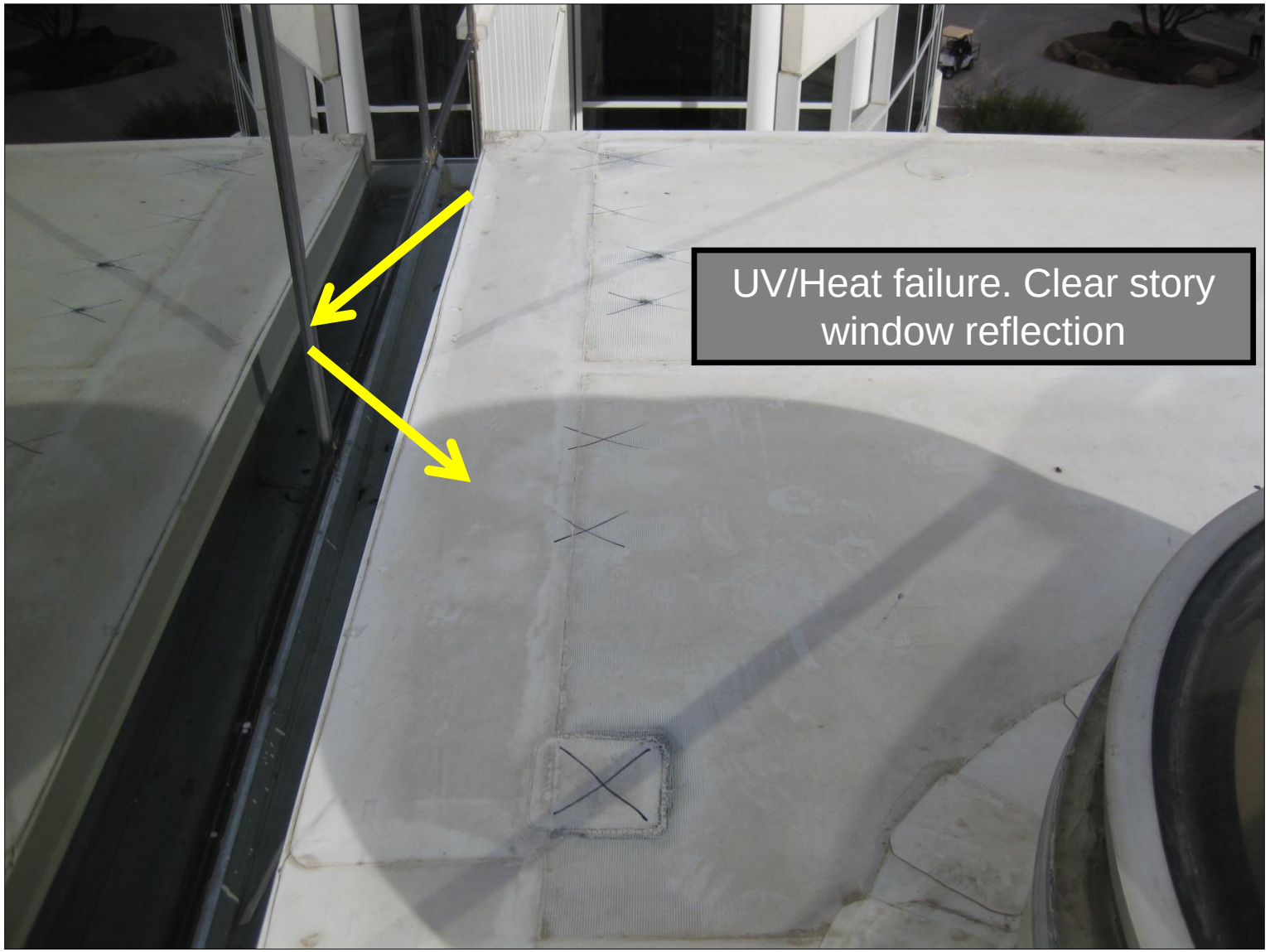
7 Years Old Carlisle, Hospital Building, Vegas



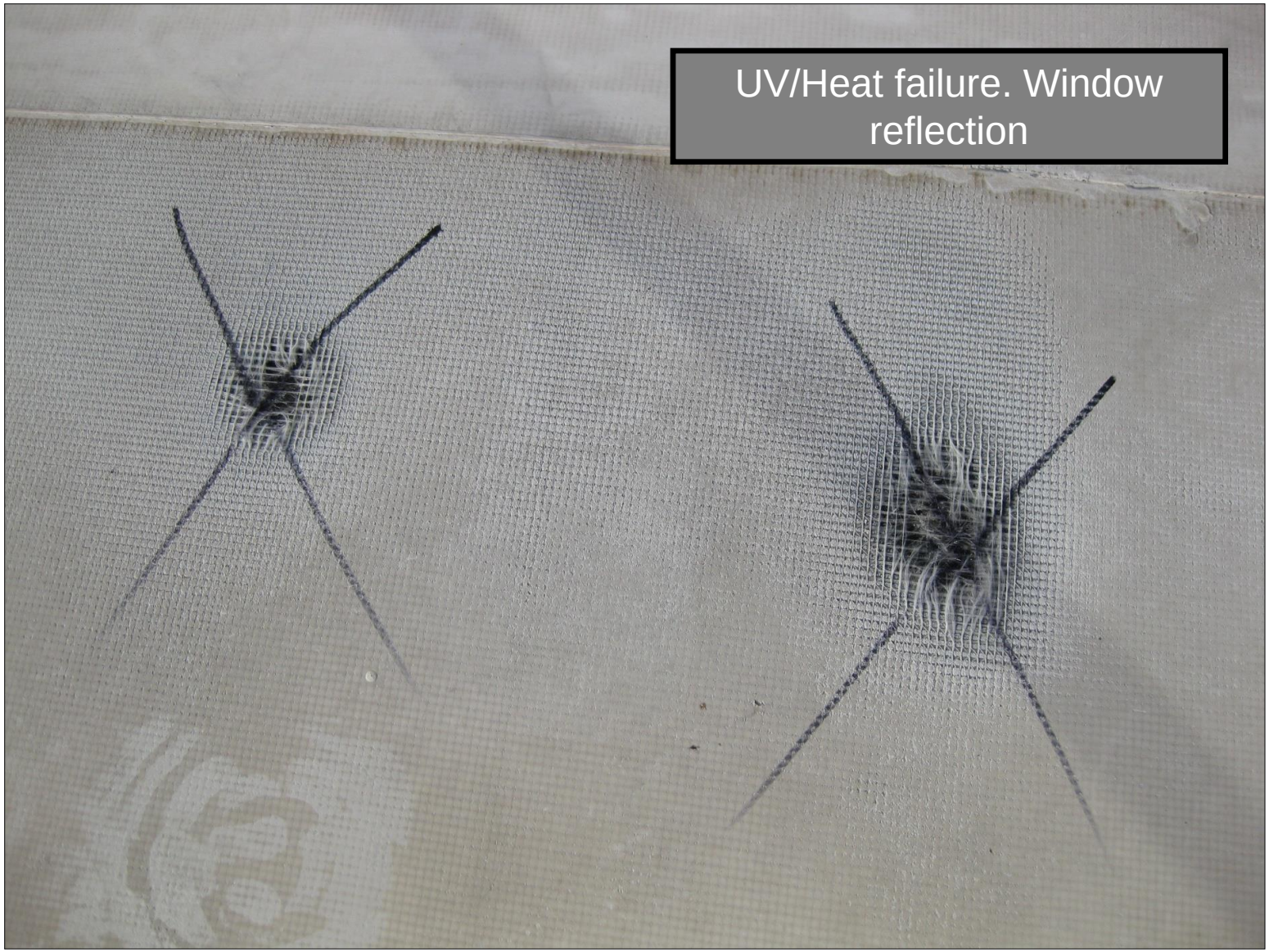
UNLV, LBC Building, GAF 7 Years Old

UNLV, LBC Building, GAF 7 Years Old

UNLV, BSL Bridge Way, Carlisle, 10 Years Old

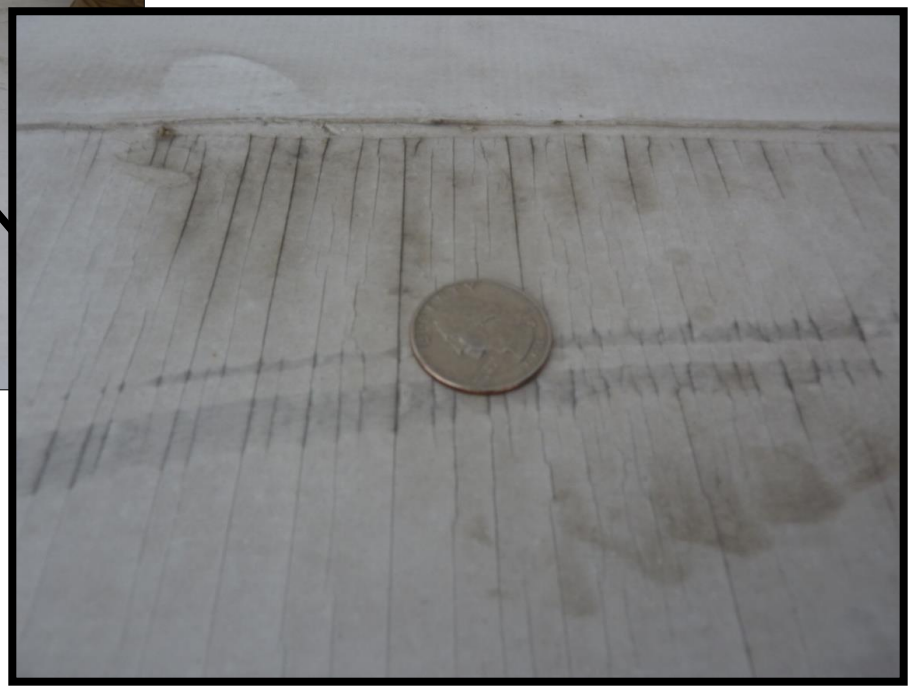


UNLV, BSL Bridge Way, Carlisle, 10 Years Old



Sun Reflection, GAF TPO 2.5 Years Old

GAF TPO 2.5 Years Old, Sun Reflection



This replacement GAF roof is less than 3 years old!

UNLV Bookstore, Firestone 11 Years Old

Roof has south facing stucco parapet. No heat related failures were observed

Carlisle Roof

Extensive Damage to Membrane Surrounding A/C Units

Chalking

Grease Fan

TPO Sustainability Score

- **UV – Heat Damage**
  - All membrane manufacturers suffered some level of damage
  - GAF seemed to fared the worst.
  - Firestone seemed to fare the best
  - Failures appear to be mostly adjacent to parapet walls, reflection from clear story windows and metal panels
  - More failures in hot climate zones like Las Vegas
  - GAF failure was observed in less than 2.5 years

- **Seam Crack/Split Issue**
  - Appears to be limited to some manufacturers
  - Failures were observed in JP Stevens and Johns Manville

Cause of Failure?

- **Most TPO membranes are made from same or similar base polymers, Basell**
- **Formulations vary due to different additives (or packages) which are 2% to 3% of material volume but very costly.**
- **Packages include:**
  - UV Stabilizers and absorbers
  - Light stabilizers
  - Antioxidants (May be related to premature heat failures)
  - Fire retardants
- **Different manufactures use different chemistry and ratio for additives**
- **UV stabilizers and Antioxidants may need to be improved?**

Lessons Learned

- Sustainability depends on many factors, some of which could have been due to the manufacturing process.
- Membrane's ability to handle high temperature for prolonged period of time
- High temperature hours seem to cumulate and it could take years to add up
- The reason failures vary by manufacturers could be due to the difference in the anti-oxidant packages used by manufacturers.
- Repairs may be necessary immediately
- Owners will need frequent inspections, timely repairs, and use of proper patching techniques.

Lessons Learned, Older TPO And PVC Roof

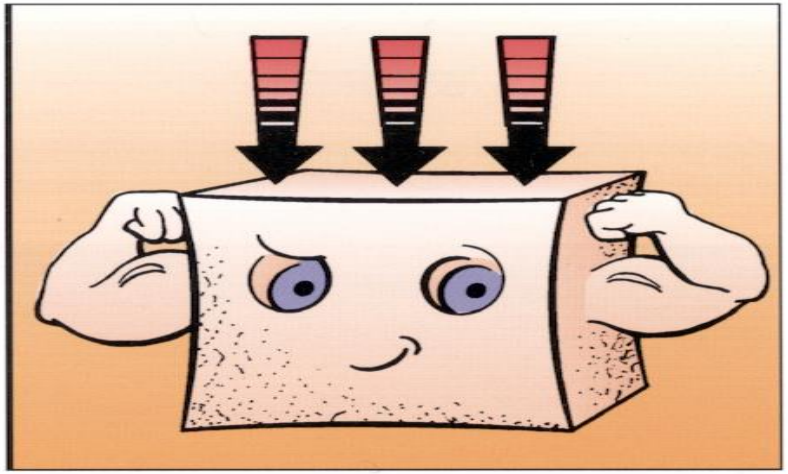
- Weldability of older TPO continues to be an issue
- Owners will need frequent inspections, timely repairs, and use of proper patching techniques.
- PVC appears to be performing better although ABB did not conduct a similar study of TPO performance in high heat/reflected areas in Las Vegas type climate. More study is needed to compare.
- Neither PVC or TPO lose appreciable membrane thickness.
- Membrane thickness loss is dependent on erosion due rain and water run-off. Less in Las Vegas due to lack of rain. More in Washington State due to higher rainfall and related errosion.

All About Concrete Spalling And Prevention

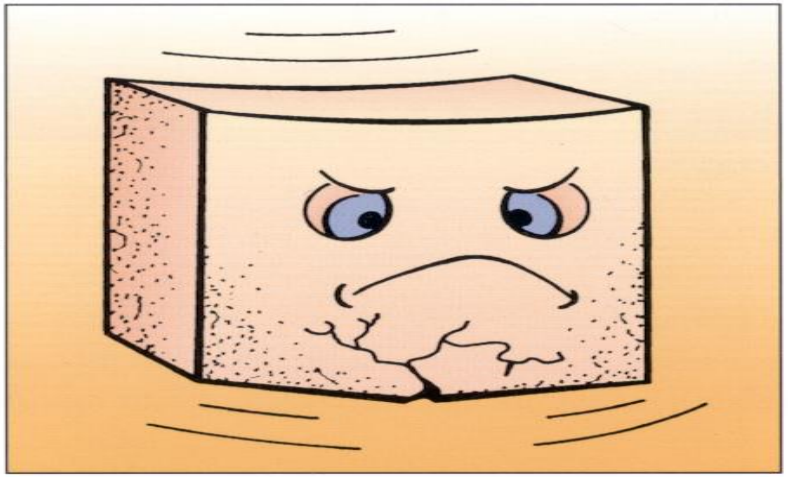
- Understanding concrete spalling
- Review repair techniques
- Spall repair cost forecasting for reserve studies
- Measures for preventing spalling

How Does Concrete Work?

Concrete is strong in compression but weak in tension. Steel reinforcing bars provide tensile strength to concrete



Concrete is Good in Compression



Concrete is Poor in Tension

Reinforcing Steel Provides “Tensile” Strength

Where Does Spalling Occur?

- Lanais, Balconies, and Terraces
- Pedestrian Walkways and Breezeways
- Recreational Decks and Plaza Areas
- Handrails, Fencing, and Gates
- Concrete Walls
- Concrete Building Exteriors
- Parking Structures

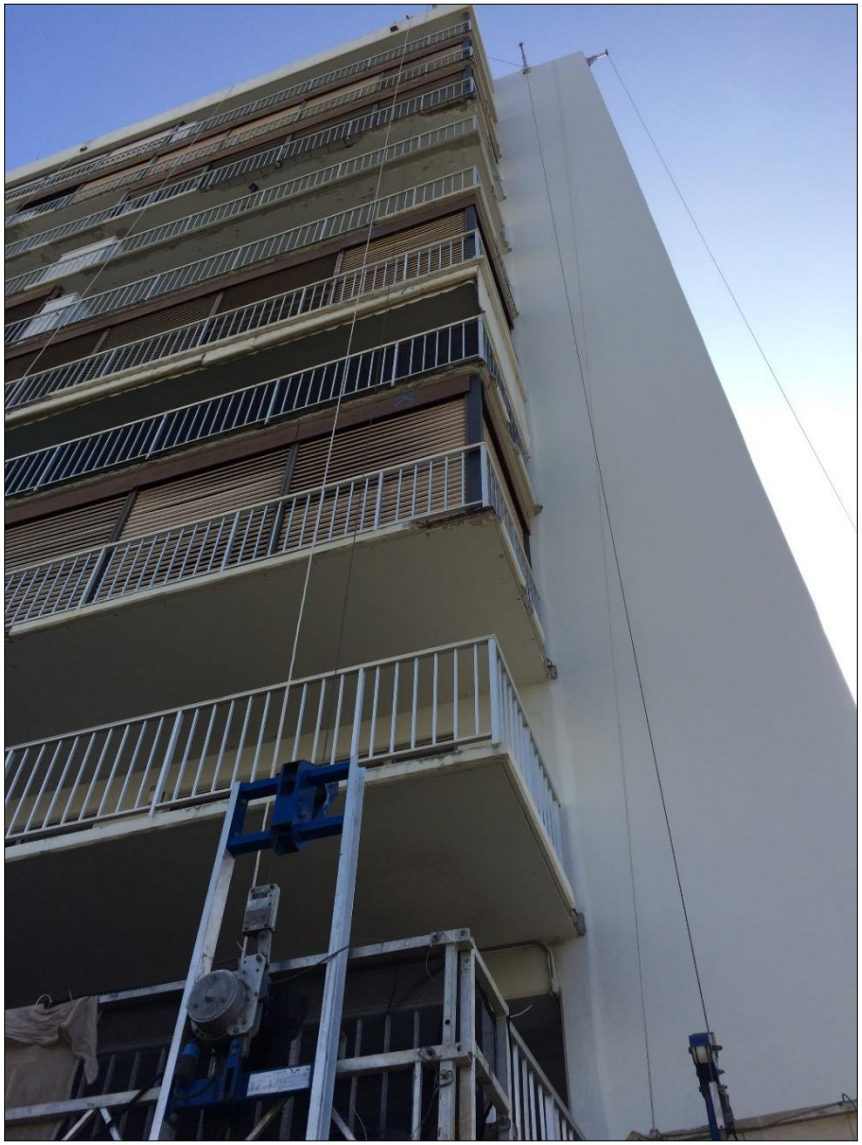
Where Does Spalling Occur?

Where Does Spalling Occur?

Where Does Spalling Occur?

Podium and plaza Waterproofing failure results in expensive spall repair in garage

Where Does Spalling Occur?



Why is Spalling Important to Address?

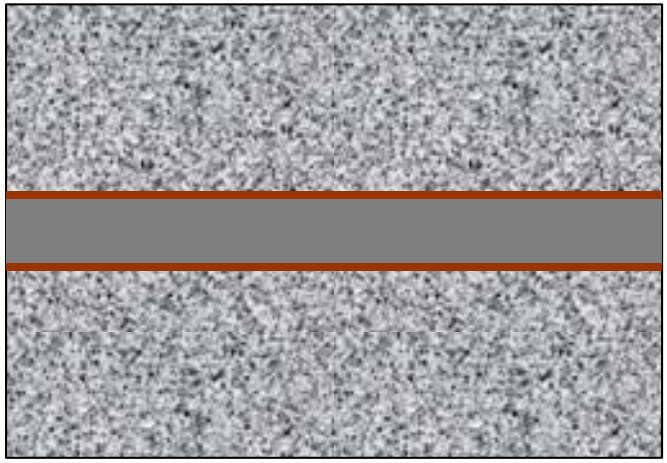
- **Concrete Spalling can be purely cosmetic or life safety**
  - Damage Reinforcement
  - Damage Connections
  - Reduce Safety Railing Capacity
  - Fall Hazard

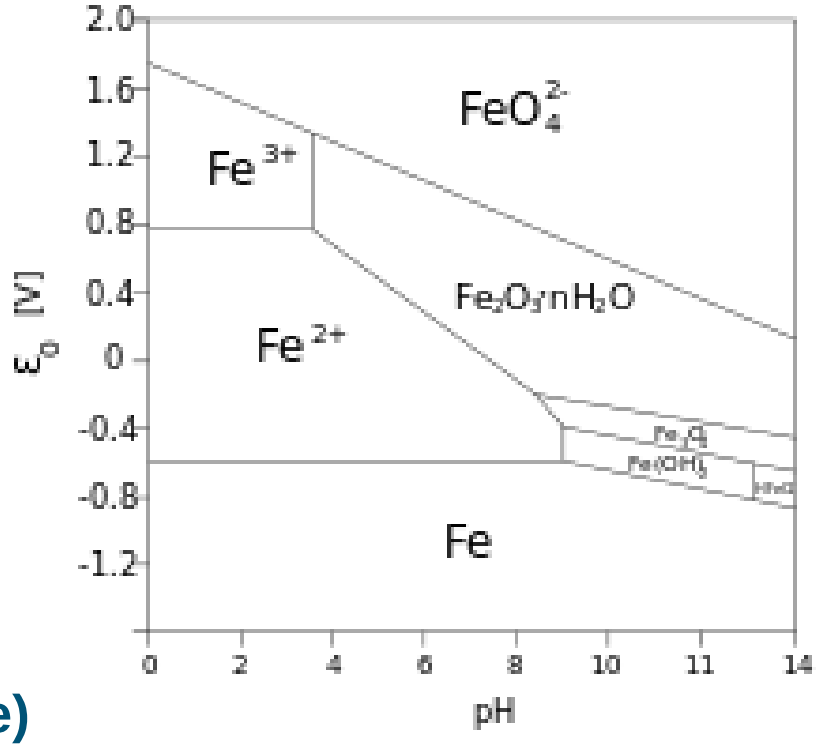
What Causes Concrete Spalling?

Common Causes Include:

- Carbonation
- Cracking and Water Intrusion
- Corrosion of Rebar/Reinforcing Steel
- Impact Damage or Seismic Activity
- Severe Environmental Impacts on Porous Aggregate
- Alkali-silica reaction (ASR)
- Reaction to aggressive chemicals
- Age of building

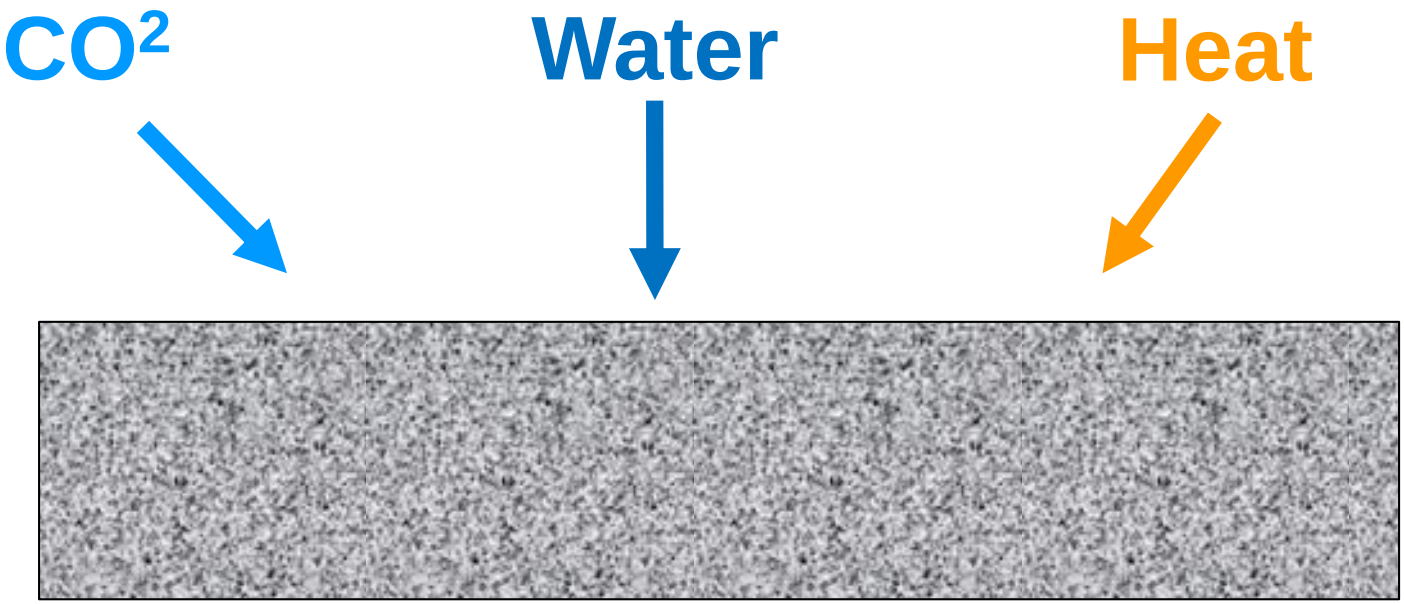
Concrete and Steel Chemistry





- Cement has a high pH
- pH of 12-14 (highly alkaline)
- At high pH a specific form of iron oxide forms on steel rebar
- This particular iron oxide provides protection from “active” electrons and corrosion
- This baring of active electrons is call “passivation”

Carbonation



Carbonation is the result of the dissolution of CO2 in the concrete pore fluid and this reacts with calcium from calcium hydroxide and calcium silicate hydrate to form calcite (CaCO3). Aragonite may form in hot conditions.

Carbonation LOWERS pH

Phenolphthalein Test For Carbonation

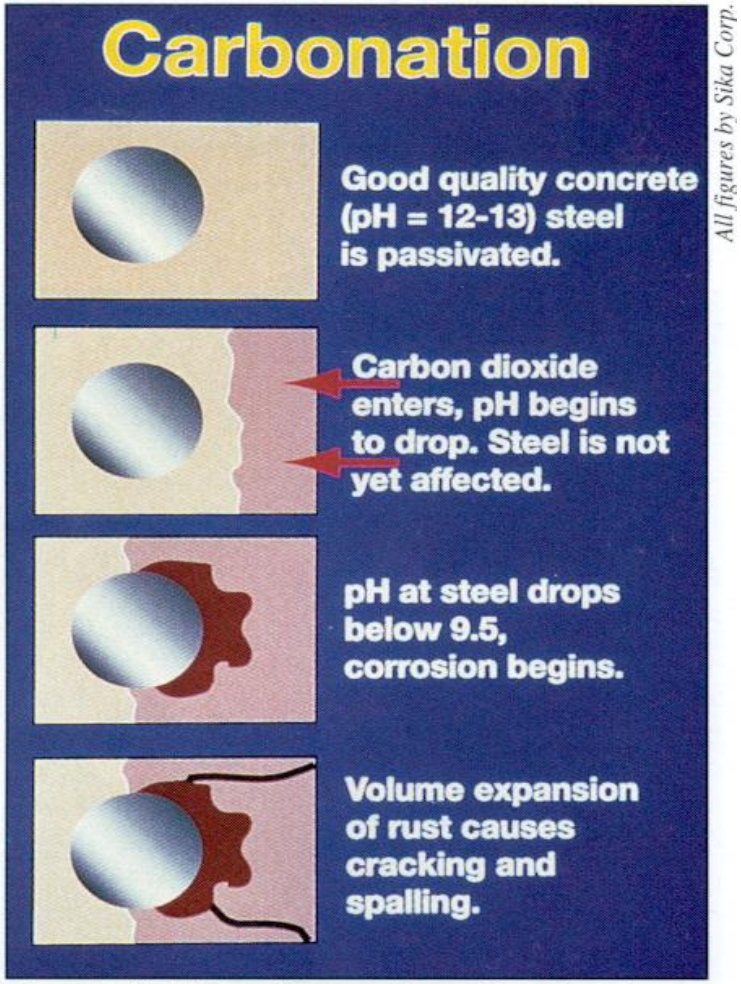
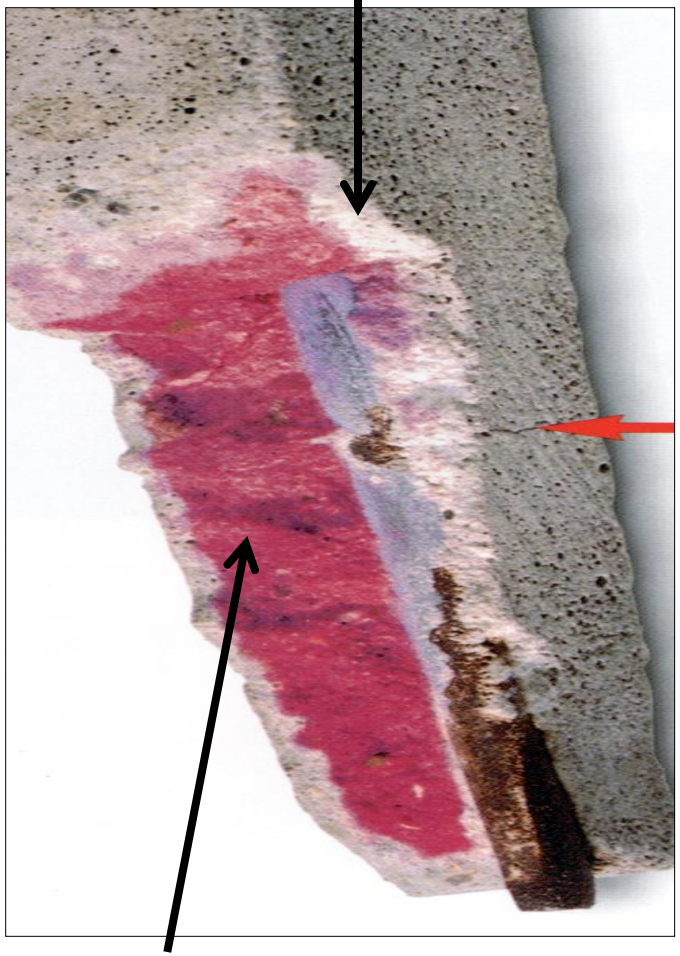


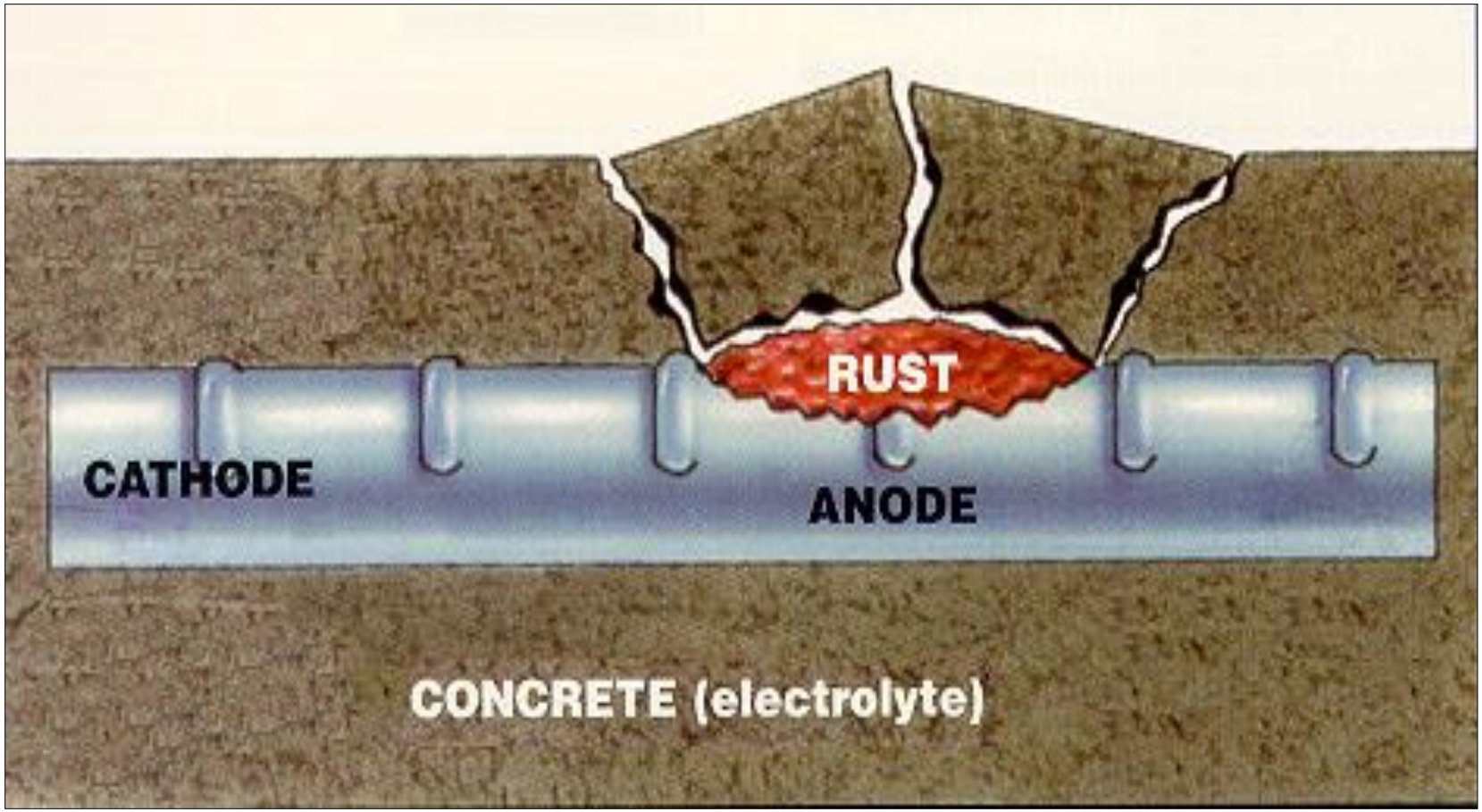
Figure 2. **When the carbonation front reaches the level of the reinforcement, the passivating oxide layer of the rebar is no longer stable, and corrosion begins.**

Clear=Carbonated

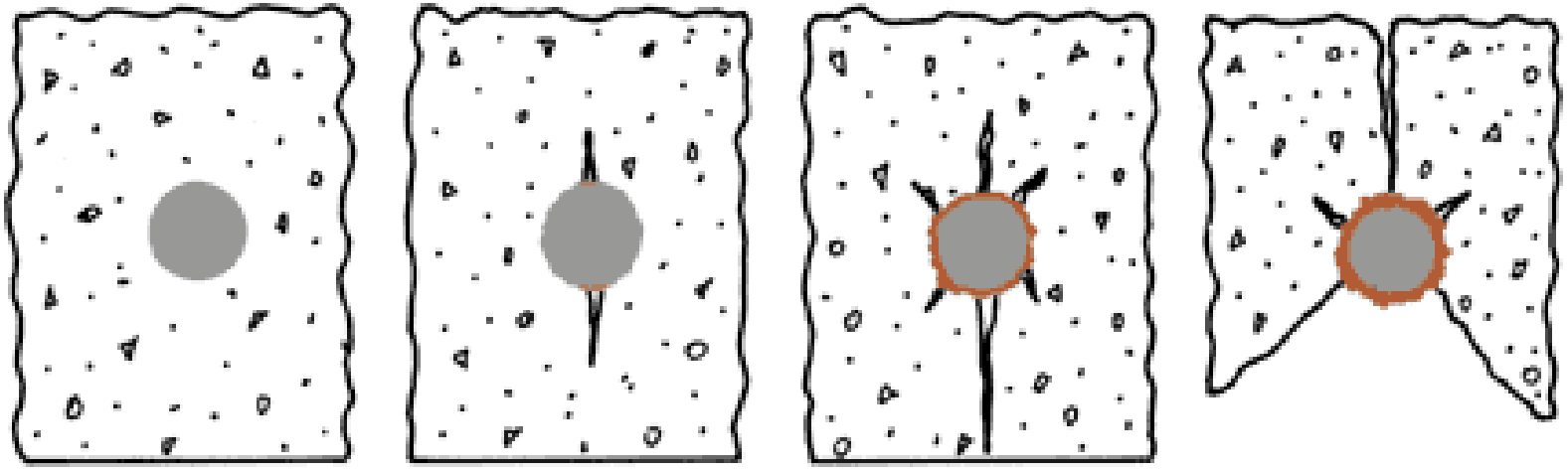


Purple=Not Carbonated

Water Intrusion and Corrosion



Water Infiltration and Spalling



Before Corrosion

Build-up of Corrosion Products

Further Corrosion: Surface Cracks, Stains

Eventual Spalling, Corroded Bar Exposed

Factors That Accelerate Corrosion

- Once concrete loses its alkalinity, rebar (steel) becomes susceptible to corrosion
- Salts and sodium ions accelerate corrosion, like sea water and high humidity
- Water intrusion through cracks in concrete accelerates corrosion
- Hawaii atmosphere is heavy with high humidity and salt (sodium)
- Important…you double a reaction rate every time you raise the temperature by 10°C

Factors That Can Prevent Corrosion and Spalling

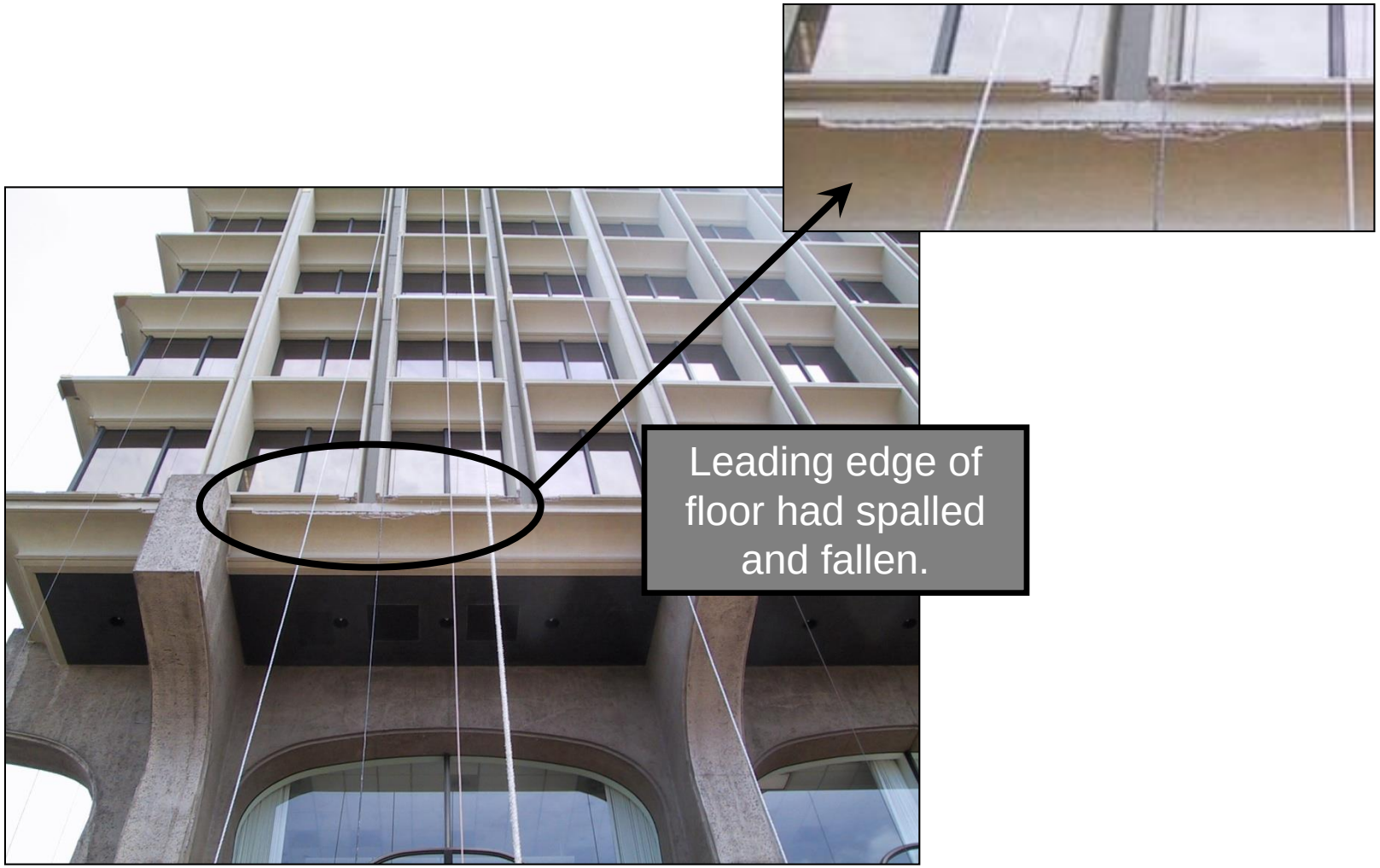
- It takes carbon dioxide to “carbonate” the concrete, which is present in air
- Concrete carbonates slowly from outside-in. Deeper the rebar, longer it takes to corrode
- Ordinary paint allows carbon dioxide to permeate through the paint
- Most elastomeric coatings block carbon dioxide, preventing carbonation
- Repairing spalls, sealing cracks and coating with good quality elastomeric can make concrete more susceptable

Repairing Concrete Spalls

- **Typical Spall Repair Project Process**

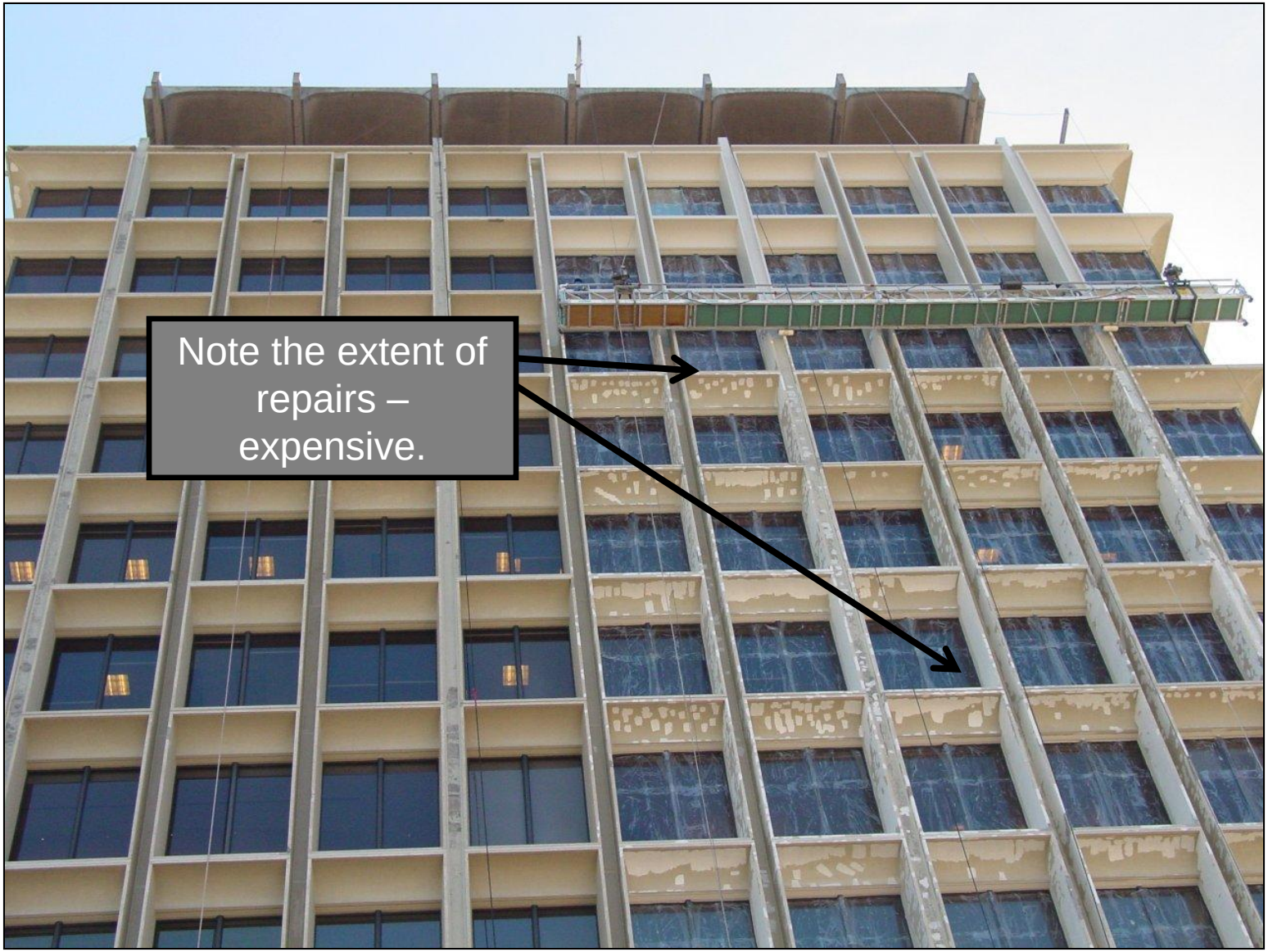
1. Survey the building exterior
2. Catalog type and extent of spalls/damage
3. Develop repair matrix and estimated costs
4. Review with project owner
5. Develop phasing schedule
6. Prepare construction documents
7. Prepare unit pricing schedule with base quantities
8. Bid project
9. Construct
10. Monitor ongoing work to confirm unit quantities and quality of repair work

Survey

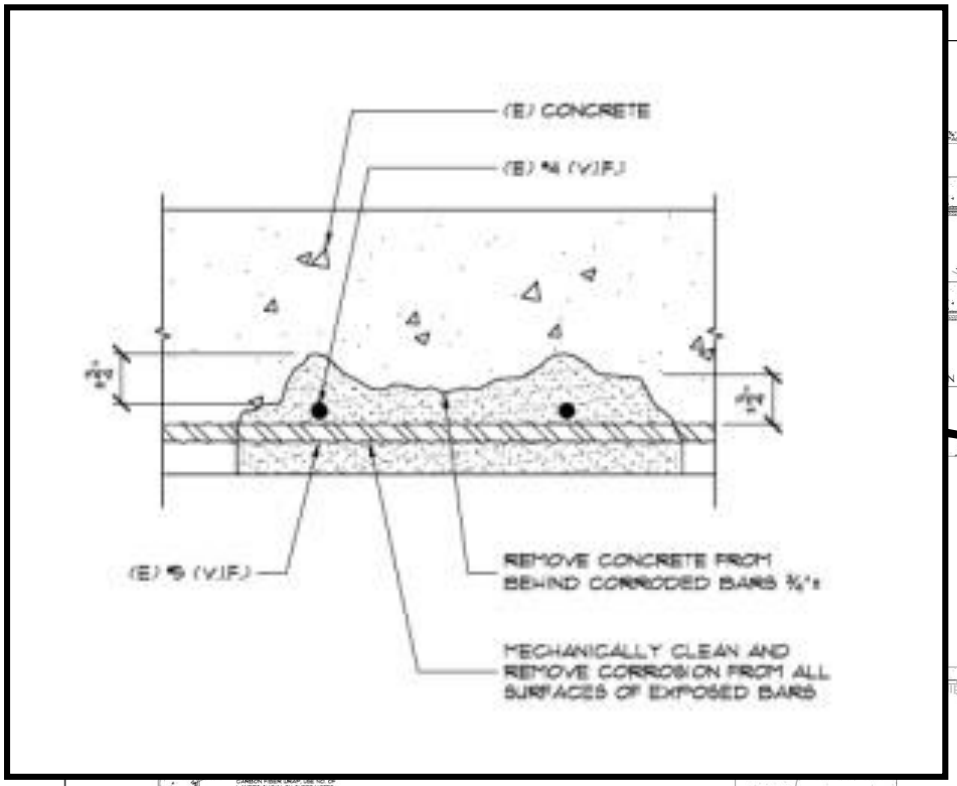


Finding Concrete Spalls

Define Extent of Concrete Spall Repair



Use Proper Design Details



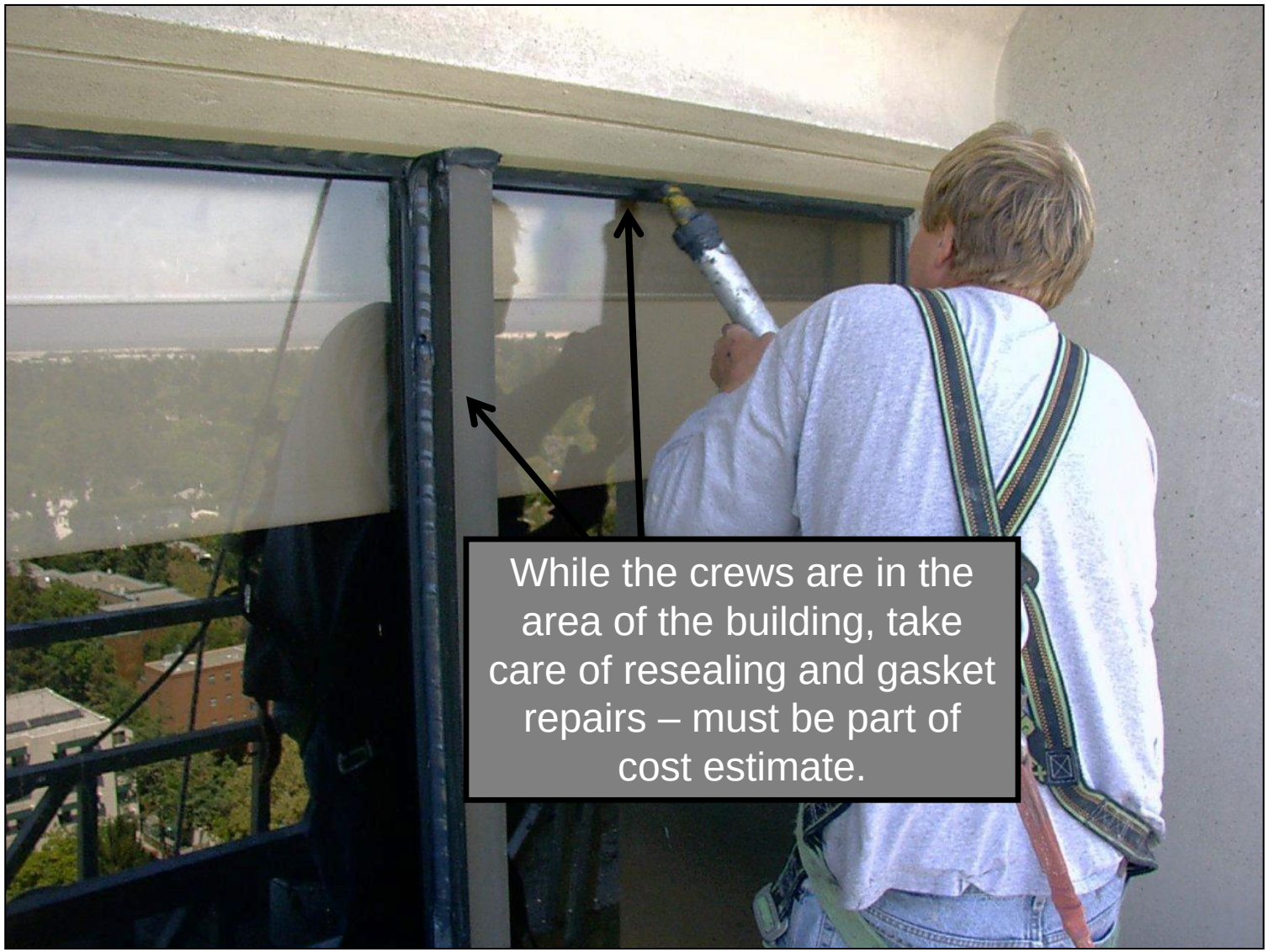
Repairs to Concrete

Proper Preparation

During Repairs

Attention to Detail - Failed Spall Repair

Not Just Spall Repairs – Seal and Coat



Old Layers of Paint Allow CO2 And Trap Water

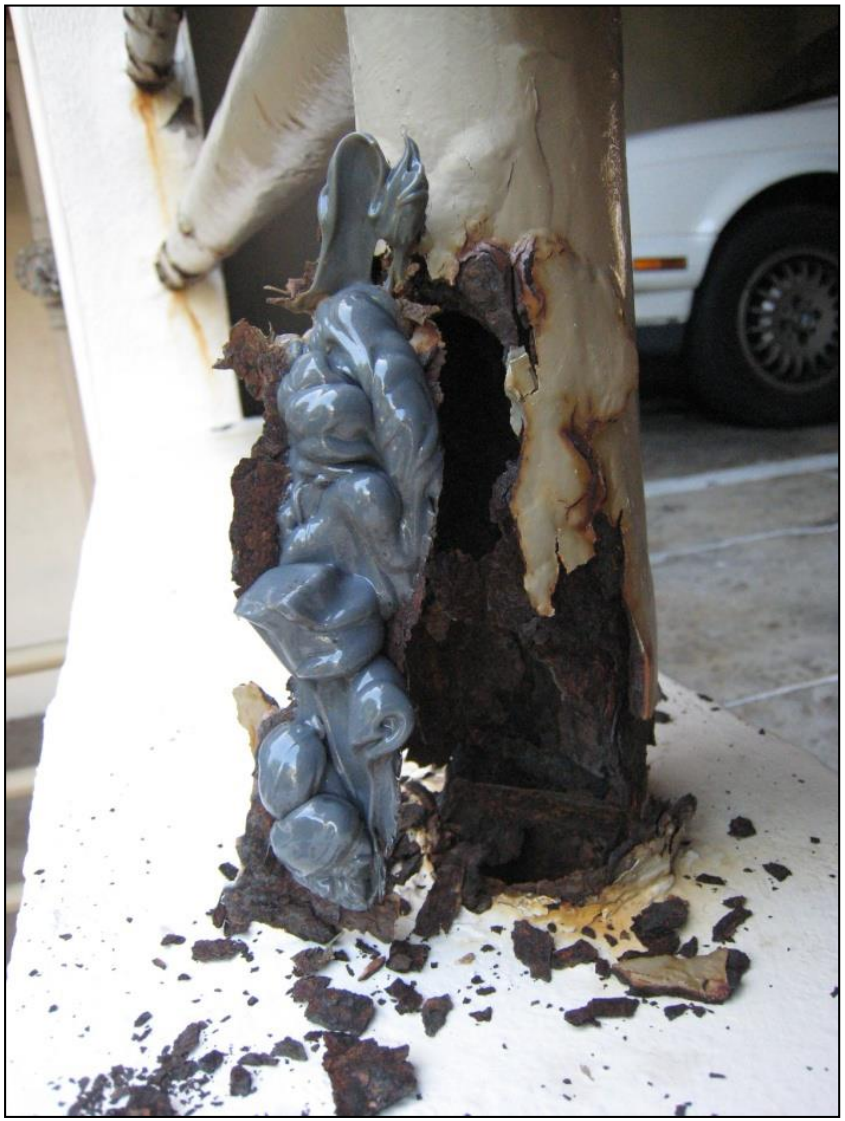
Spalls Around Hand Rails is Life Safety Risk

J.W. Marriott Ihilani Resort & Spa
Kō Olina, O'ahu

Handrail Corrosion and Spall is Life Safety

Spookier Than Halloween!

Inappropriate Repairs



Worker and Pedestrian Safety Adds to Cost

Projecting Spall Repair Pricing

- Periodic condition studies (every 5 years)
- Engineering services for project design
- Appurtenance construction (railings)
- Pedestrian and tenant protection
- Horizontal work (parking and other deck coatings)
- Window repairs (sealants, glazing and gaskets)
- Protective coatings for repaired concrete
- Construction observation and project management

Projecting Spall Repair Pricing

- **Recent Unit Pricing Experience**
  - Overhead Repairs: $.48 to $.75 /$in^3$
  - Horizontal Repairs: $.20 to $.50 /$in^3$
  - Epoxy Injection: $110 to $150 /ln ft
  - Sealant Replacement: $12 to $10/ ln ft
  - Removal of Paint Coatings: $4 to $6 /sf
  - New Coatings: $3.50 to $6.00/sf
  - Parking Deck Coatings: $12 - $35/sf

Preventing Corrosion and Spalling

- Regular preventive maintenance
- Fix small problems before they grow
- Remove standing water – fix drainage
- Apply and maintain protective coatings
- Removal of Paint Coatings: $4 to $6 /sf
- New Coatings: $3.50 to $6.00/sf
- Parking Deck Coatings: $12 - $35/sf

Preventing Corrosion and Spalling

Polyurethane Elastomeric Coatings are tough, high tensile strength (500 to 1500 psi) and can stretch 200% to 500%

Preventing Corrosion and Spalling

Acrylic and Silicone Elastomeric Coatings are used for wall, lower tensile strength, breathable but blocks carbon dioxide

Protective Coatings, What is Important?

- **Some Required Properties**
  - Permeability: Important to allow walls to breathe and naturally dry out (not trap water)
  - Elastomeric/Stretchiness: To allow coatings to bridge cracks and flex
  - Impermeable: To NOT allow water and CO2 to intrude
  - Alkaline resistant: Concrete is highly alkaline and can degrade and damage coatings

Protective Coatings Enhanced Properties

- **Enhanced and Engineered Properties:**
  - Anti – carbonation: To prevent carbon dioxide from penetrating through coatings
  - Dirt pick -up resistance: Some coatings pick up more dirt than others, aesthetic
  - Long term weathering capabilities: UV and rain degrade coatings. How resistant is the coating to the environment sustainability and longevity)
  - Coating film thickness: Every coating requires minimum thickness to perform for elongation, carbon dioxide resistance, etc.
  - Color retention and resistance to fade

Lessons Learned

Selection of Coatings and Sealants

- Sealants and coatings are engineered.
- Not all products are created equal.
- Check enhanced properties of materials.
- Proper selection of materials and thickness and double the life of coatings

Embedded and Mounted Accessories

- Proper detailing and construction methods can double or triple the life of materials

Keys To Sustainable Assemblies

- **Window Wall and Other Fenestration:**
  - IGU with proper dual seals
  - High quality “seals” made with extruded silicone as opposed to recycled EPDM
  - Proper design of window system
  - Proper selection of materials and assemblies
- **Aluminum Coatings and Anodizing:**
  - Class 1 anodization. Proper specification and verification
  - Quality and application of paint or coatings (Kynar/powder coating)
- **Plumbing Systems:**
  - Good quality workmanship, proper copper welding
  - Maintenance of sewer pipes and cleaning
  - Inspection and replacement of failed joints and assemblies
  - Repair or replace with alternative materials
  - Pipe lining technology, use it wisely

Keys To Sustainable Assemblies

- **Roof longevity is dependent on:**
  - Selection of roofing membranes that resist sun, wind and water
  - Proper construction, to prevent “premature” leaks in flashings and drains that require repairs and maintenance
  - Flashings that are not constructed with an inherent need for frequent maintenance to keep them water tight
  - Redundant assembly with belt and suspenders
- **Concrete spalling and prevention:**
  - Nothing can replace proper workmanship in spall repairs and coatings
  - Selection of coating, patching and sealant materials
  - Proper inspection, identification and repair
  - Prevent spalls and future cost of repair by applying coatings before spalls occur
  - Best to remove old paint and coatings, fix all underlying issues