



# Roofs Can Last In Excess of 30 Years But Most Do Not

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# Karim P. Allana, PE, RRC, RWC

- **Education:** B.S., Civil Engineering, Santa Clara University
- **Registration:** P.E., Civil Engineering, California, Washington, Nevada, and Hawaii
- **Certification:** Registered Roof Consultant (RRC), Roof Consultants Institute, and Registered Waterproofing Consultant (RWC)



- **Overview:**
  - CEO and Senior Principal at Allana Buick & Bers.
  - Former Turner Construction Employee (Project Engineering and Superintendent)
  - Over 37 years experience providing superior technical standards in all aspects of building technology and energy efficiency.
  - Principal consultant in forensic investigations of building assemblies, failure analysis, evaluation and design of building infrastructure and building envelope evaluation and design.
  - Expert in all aspects of building envelope technology.
  - Completed numerous new construction, addition, rehabilitation, remodel and modernization projects for public and private sector clients.
  - Specialization in siding, roofing, cement plaster, wood, water intrusion damage, window assemblies, storefronts, below grade waterproofing, energy efficiency, solar engineering and complex building envelope and mechanical assemblies.



# ABBAE Firm Overview

- Allana Buick & Bers (ABBAE) is an Architectural Engineering firm specializing in Building Envelope Systems
- ABBAE is one of the 5 largest building envelope consultants in the country
- ABBAE has over 33 years of experience & over 12,500 projects
- ABBAE is also a leading Forensic Defect firm with hundreds of forensic projects (litigation)
- Locations – 16 offices across California, Nevada, North Carolina, Oklahoma, Oregon, Texas, Virginia, Washington, Colorado and Hawaii



# Staff & In-House Expertise

- Licensed Professional Engineers – Civil, Structural, and Mechanical
- Registered Architects
- Building Enclosure Commissioning Process Providers (BECxPs)
- Registered Building Envelope Consultant (RBEC)
- Registered Roofing Consultants (RRCs)
- Registered Waterproofing Consultants (RWCs)
- Registered Exterior Wall Consultant (REWCs)
- Registered Roof Observers (RROs)
- Certified Exterior Insulation and Finish System (EIFS) inspectors
- Curtain Wall Specialists
- ICC Certified Building Inspectors
- Quality Assurance Monitors
- Water Testing Experts
- Leak Investigation and Diagnosis Experts
- Infrared Imaging and Nuclear Moisture Scanning Experts

# ABBAE Building Expertise

- Building Envelope Systems

- Roofing Systems
  - High-Slope/Low-Slope Roofs
  - Green/Garden Roofs
  - Drainage Systems
  - Pedestrian Plazas
- Exterior Wall Systems
  - Wall Cladding/Siding/GFRC/pre-cast
  - EIFS/cement plaster/stucco
  - Sheet Metal Flashings
- Windows and Glazing Systems
  - Punched Windows
  - Curtain Wall/Window Wall Systems
  - Sliding Glass Doors
  - Skylights

- Building Envelope Systems (cont'd)

- Roofing & Waterproofing Systems
  - Deck/Balcony/Lanai Waterproofing
  - Podium Waterproofing
  - Pool/Spa Deck Waterproofing
  - Above-Grade/Below-Grade Waterproofing
  - All types of low and steep sloped roofing
- Commissioning BECx
  - OPR/BOD/Commissioning Plan
- Mechanical/HVAC Systems
  - HVAC design
  - Plumbing systems
  - Commissioning and testing

# ABBAE Core Services

- Consulting and third-party peer review services
- Engineer of record for building envelope systems
- Contract administration services
- Inspection services (usually direct with owner)
- Air and water performance testing
- Mock-up design, observation, and testing
- Building assessments and forensic investigations
- Litigation support and expert witness services
- Educational seminars with AIA credits



# Outline of Presentation

- In this seminar, we will review:
- Examples of 30+ year old sustainable traditional BUR
- Examples photos of bad roof construction contrast with proper details and methodology
- Forensic evaluation of some of the oldest PVC (18 years old) and TPO (12 years old) roofs
- Evaluation of a 12 year old SBS Roof membrane premature failure
- Case Study of a 12 year old copper roof failure and repair

# Overview

- The Design-Build role that most roofing contractors assume without even knowing it.
- The difference between:
  - DESIGN DEFECTS
  - CONSTRUCTION DEFECTS
  - LACK OF ROOF MAINTENANCE
- How the 10 year statute of limitation applies to construction defects and leaks in various states.
- The difference between normal warranty and “implied” warranty.



# Roofs can and do last 30+ years

- Traits of 30+ year roofs:
- Good UV protection. Gravel surfacing, renewable acrylic coating, etc.
- Good Design. Details such as drains, sleepers, base flashings, all designed to last 30+ years, not just the membrane.
- Proper slope to drain.
- Proper securement of roof and insulation
- Stable substrate such as concrete, Lt Wt Insulating Concrete, or insulation over plywood or metal.
- Protection from physical damage, excessive traffic, hail, etc.



# Hot Applied Built Up Roofing (BUR)



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# Hot Applied Built Up Roof (BUR)





- BUR systems are field applied and quality control is essential for longevity



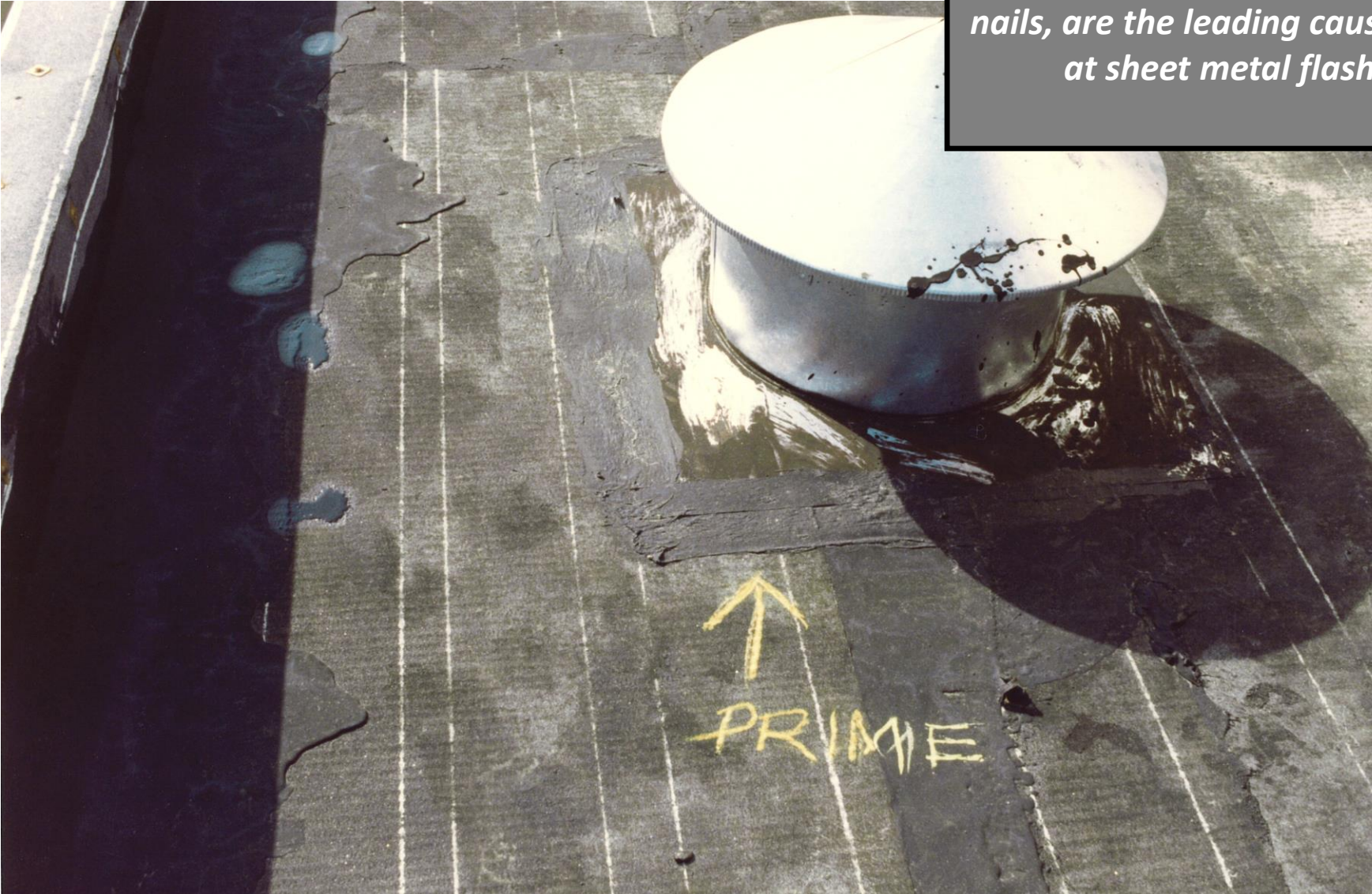




***DEFECT: Lack of brooming of felts and improper asphalt temperature causes voids and poor saturation of roof plies.***



***DEFECT: Improper application of primer couple with lack of sufficient nails, are the leading causes of leaks at sheet metal flashings.***






*Edge flashing at 34 year old roof is splitting, due to improper workmanship (fastening). Embedded edge metal require fastening at 3"o.c. staggered, absence of which results in splitting at joints in metal*





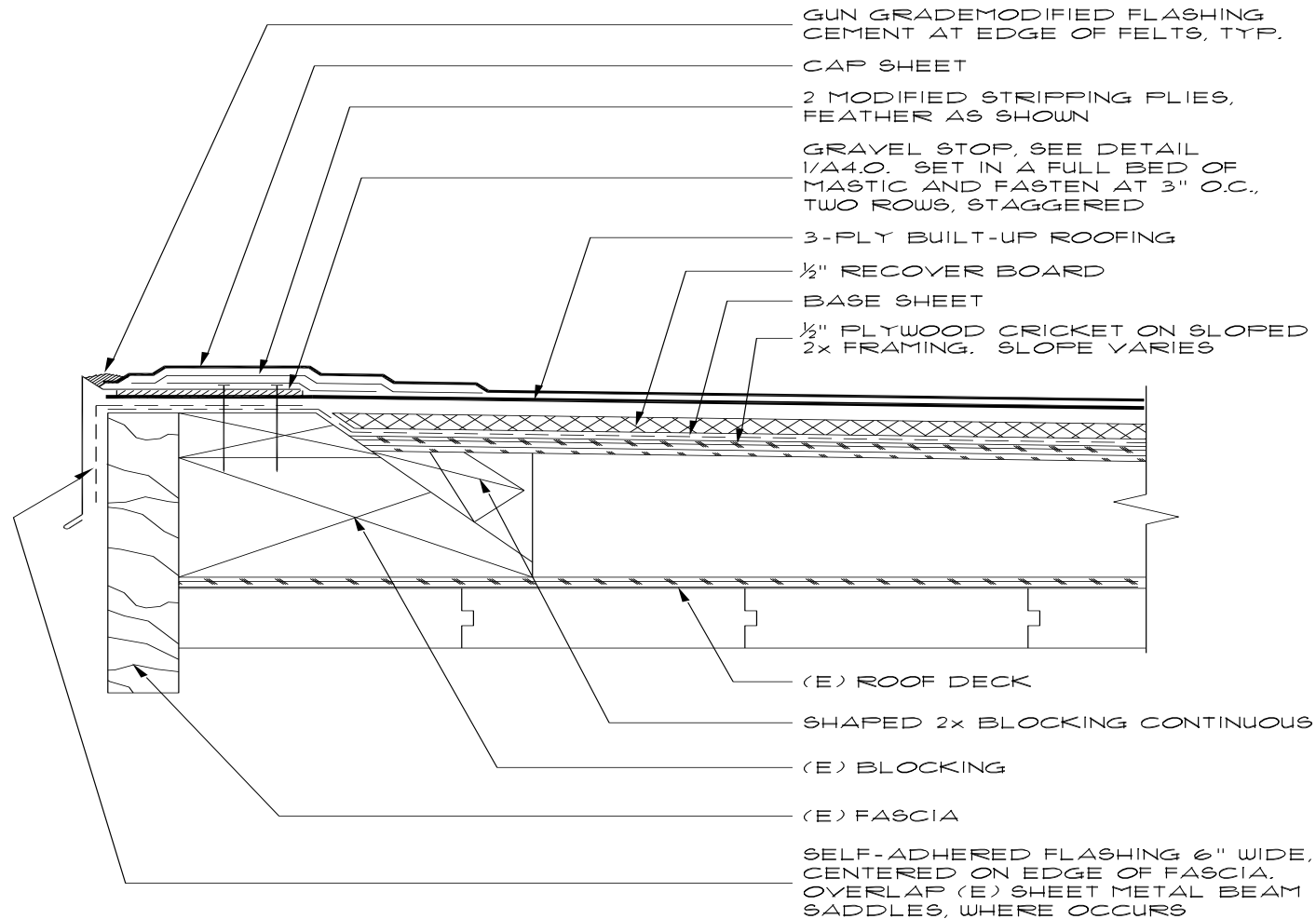


*Same type of flashing, upon close examination of the edge flashing joint of a 32 year old roof shows no sign of splitting.*

- 
- Proper design and construction includes:
  - stripping in the metal with two or three plies
  - priming the metal on both sides
  - setting the flange in mastic on top of the membrane
  - fastening the metal 3” on center.



# Non-insulated Eave Metal – Built Up Roof





# ATTACHMENT

- Proper attachment of roofing system is essential.
- Membrane attachment with mechanical fasteners or with adhesion
- Insulation attachment with fasteners and discs or approved adhesive over substrate
- Proper attachment of substrate



*National Guard Armory, San Diego,  
33 years old, no leaks. Built with  
traditional materials.*





*A county administrative building in California, 34 years old, two minor leaks*





*Test cut of same roof reveals  
excellent gravel surfacing,  
membrane is spot mopped to primed  
concrete deck, i.e. proper securement  
to substrate*



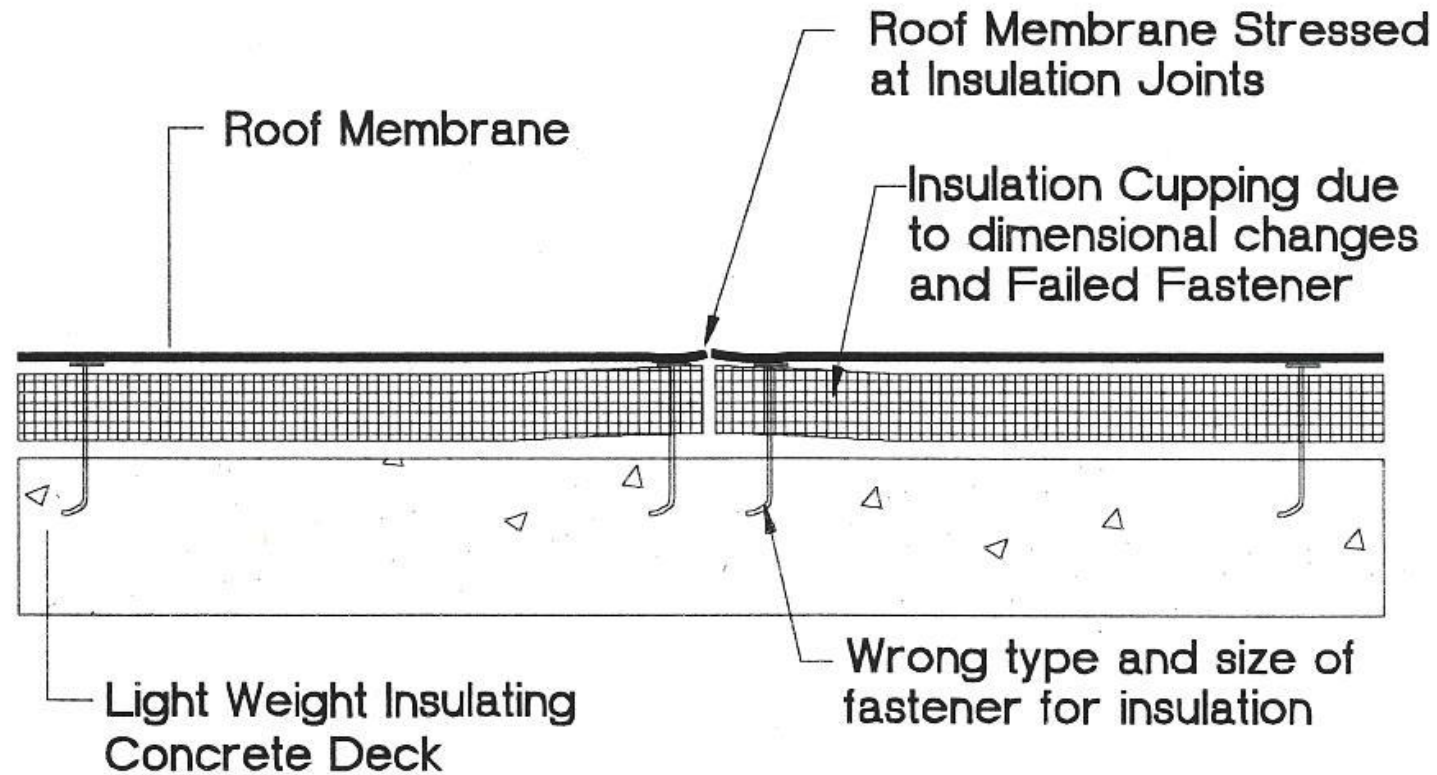


*A very expensive roof at a major west coast university, failing after only five years. Roof is “picture framing” and ridging*



***DEFECT: Improper securement of roof. Inappropriate insulation fasteners, poorly installed, causing cupping of insulation material.***





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



# Proper Slope and Crickets are essential



*Crickets are undersized in some locations, or not provided at all. Need to be deeper and redesigned. Note deterioration.*





# Ponding Water Leads to Deterioration





# Pipe Penetrations

*Two examples of conduits installations that were not designed – installed without proper flashing.*





# Base Flashing Condition



*Base flashings were not surfaced with a protective layer or cap sheet. Granules on the cap sheet protect the membrane from UV rays. Base flashings are also exhibiting signs of deterioration. See photo below.*

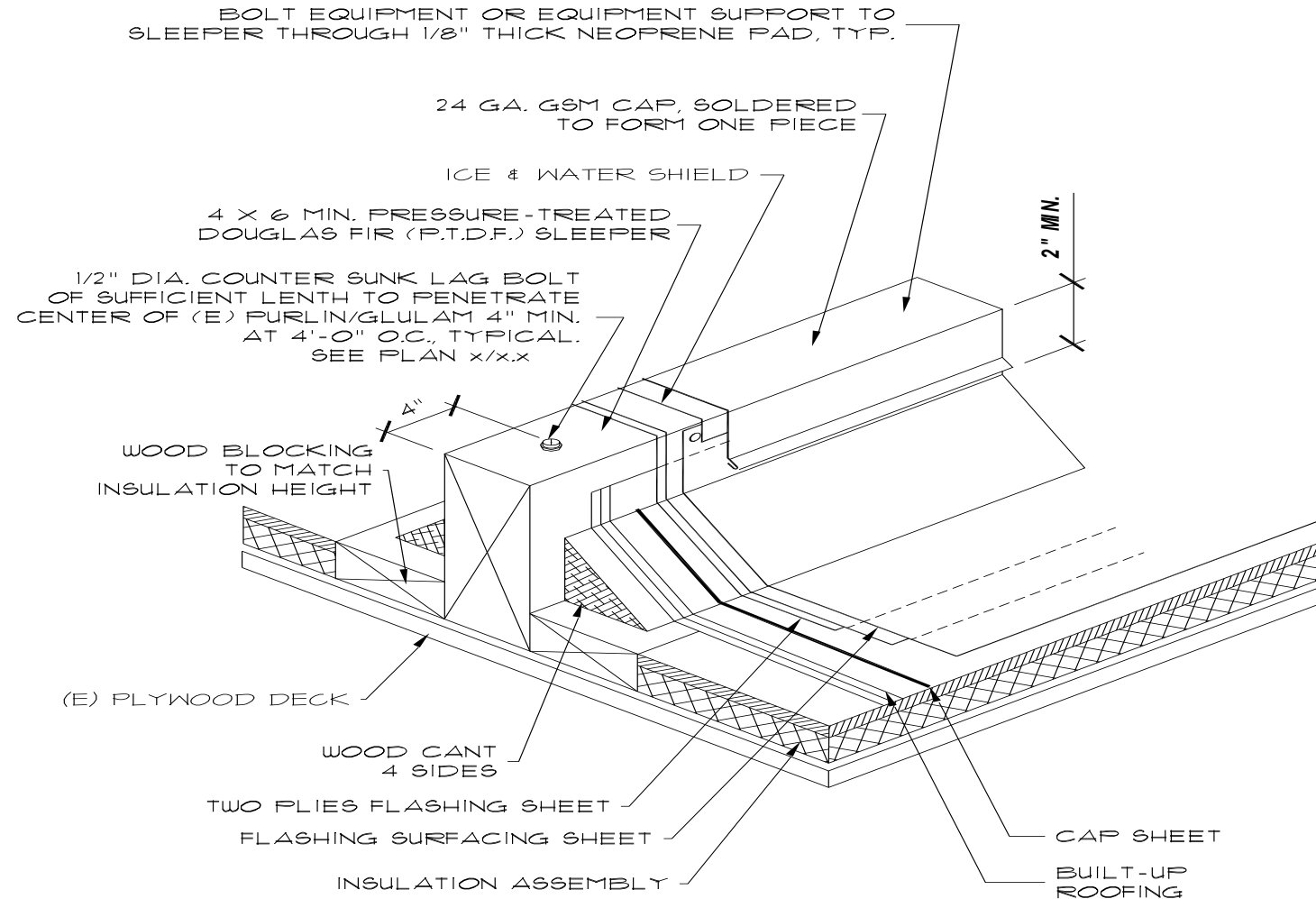




# Poor Sleeper Detail



# Roofing over Sleeper – Built Up Roofing

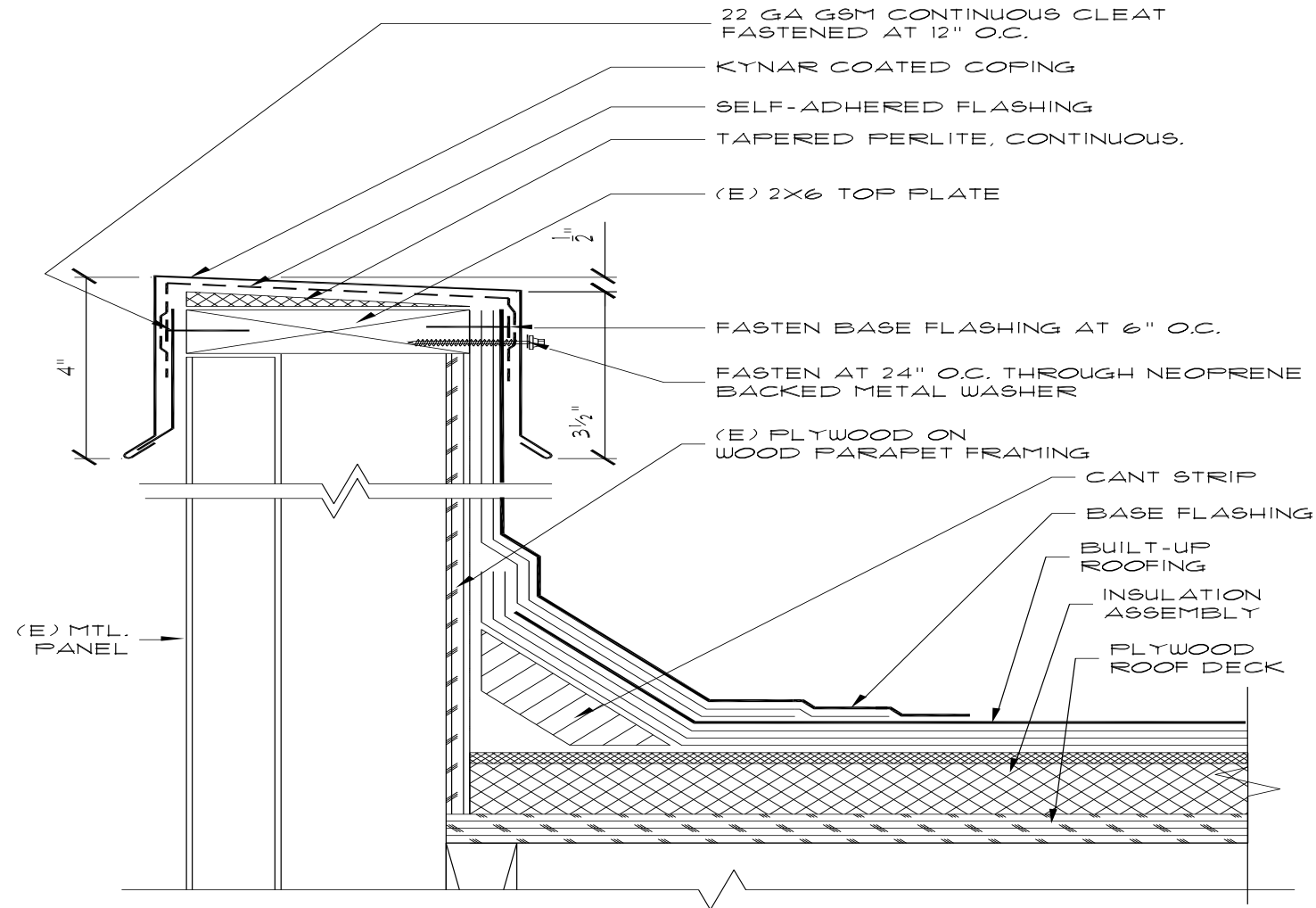




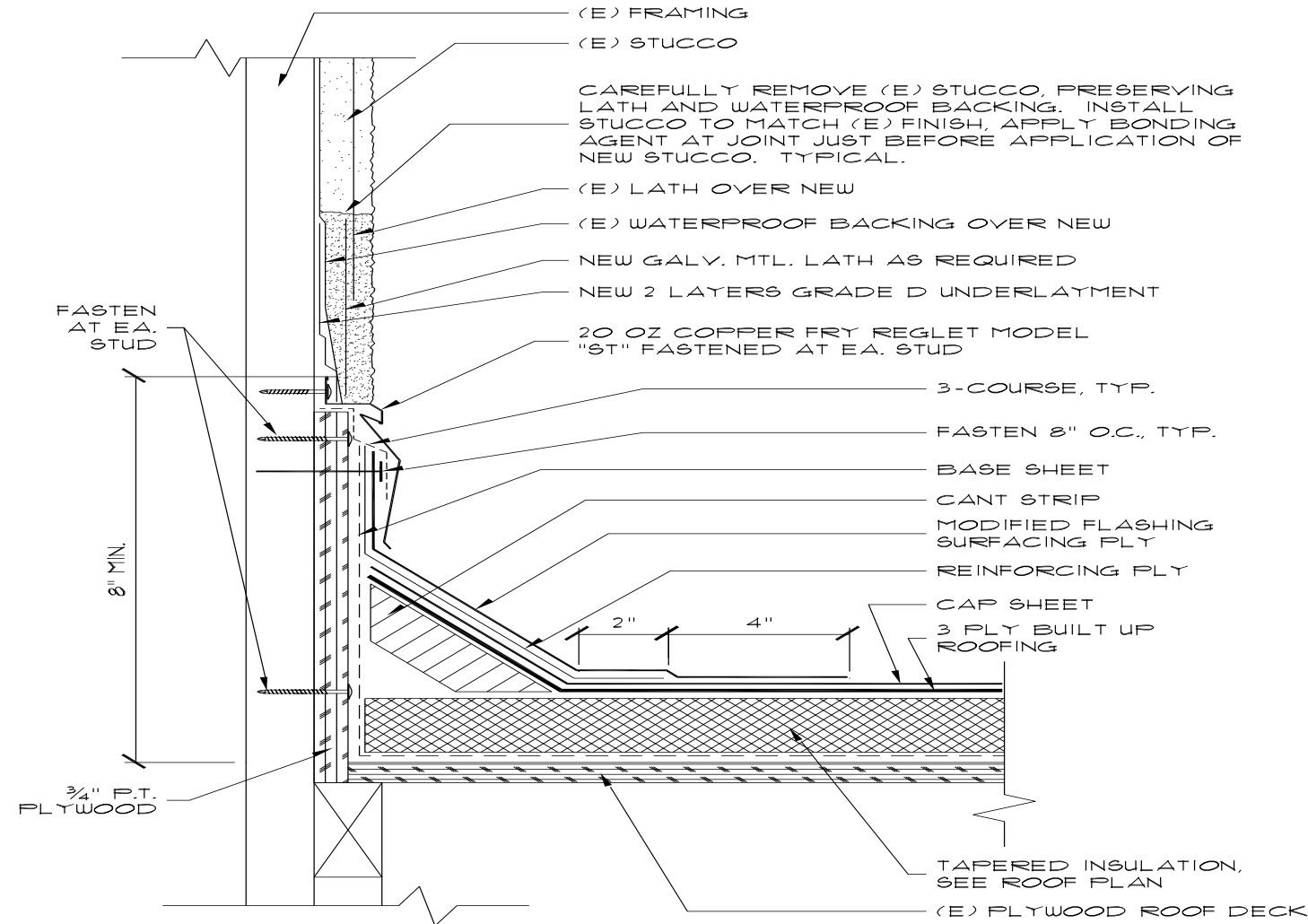
# Poorly detailed and installed parapet wall



# Parapet Flashing Detail – Built Up Roofing

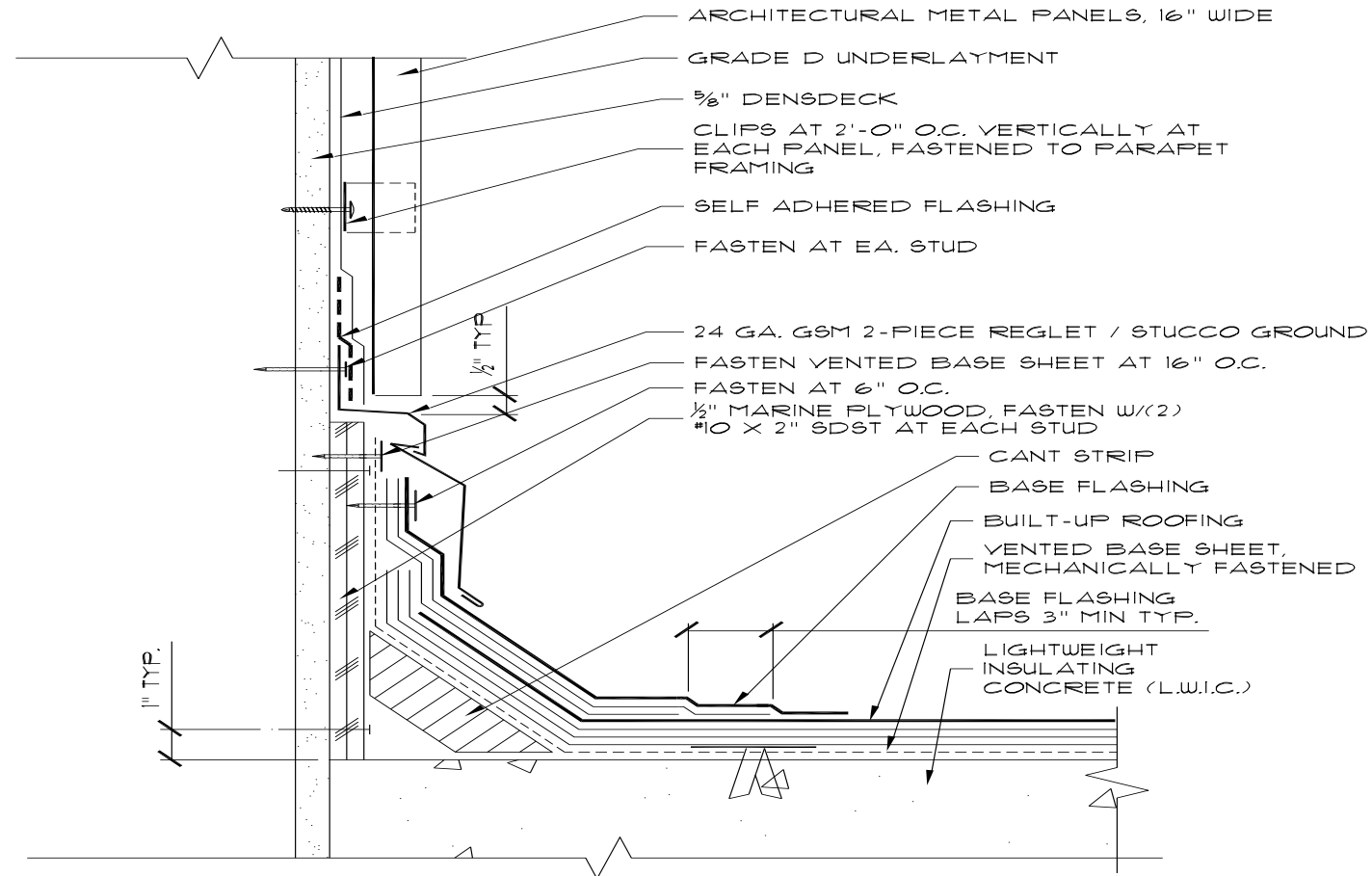


# Roof to Stucco Flashing Detail – Built Up Roofing





# Parapet Base to Roof Flashing – Built Up Roofing



## NOTES:

1. SEE DETAIL 0134 FOR COPING.
2. FOR FASTENERS SEE FASTENER SCHEDULE, DETAIL x/x.xx.



*Proper material storage is critical to the overall success of the job. Materials stored improperly can absorb moisture and cause blisters.*

# Good Roofs Are Not Accidental

*Cap sheet laps have an even splash line and appear to be properly sealed with no fish mouths. Neat and clean construction often means the applicator takes pride in his workmanship*





# Alternative Pitch pan filler?





# Built Up Roofing SBS Modified



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# SBS = Poly(styrene-butadiene-styrene)

- A synthetic rubber polymer added to hot asphalt
- Thick, coated, polyester and or fiberglass reinforced sheets are factory made and applied in the field.
- SBS has low UV resistance therefore, good UV resistive surfacing or coating is essential for its success
- Applied similar to traditional BUR, with hot asphalt, cold adhesive or torch application

# 12 Years Old SBS Roof with Capsheet





# Test Cut: Observe crazing on surface





# New, Hot Applied SBS Smooth Sheet







# Foam Roofing



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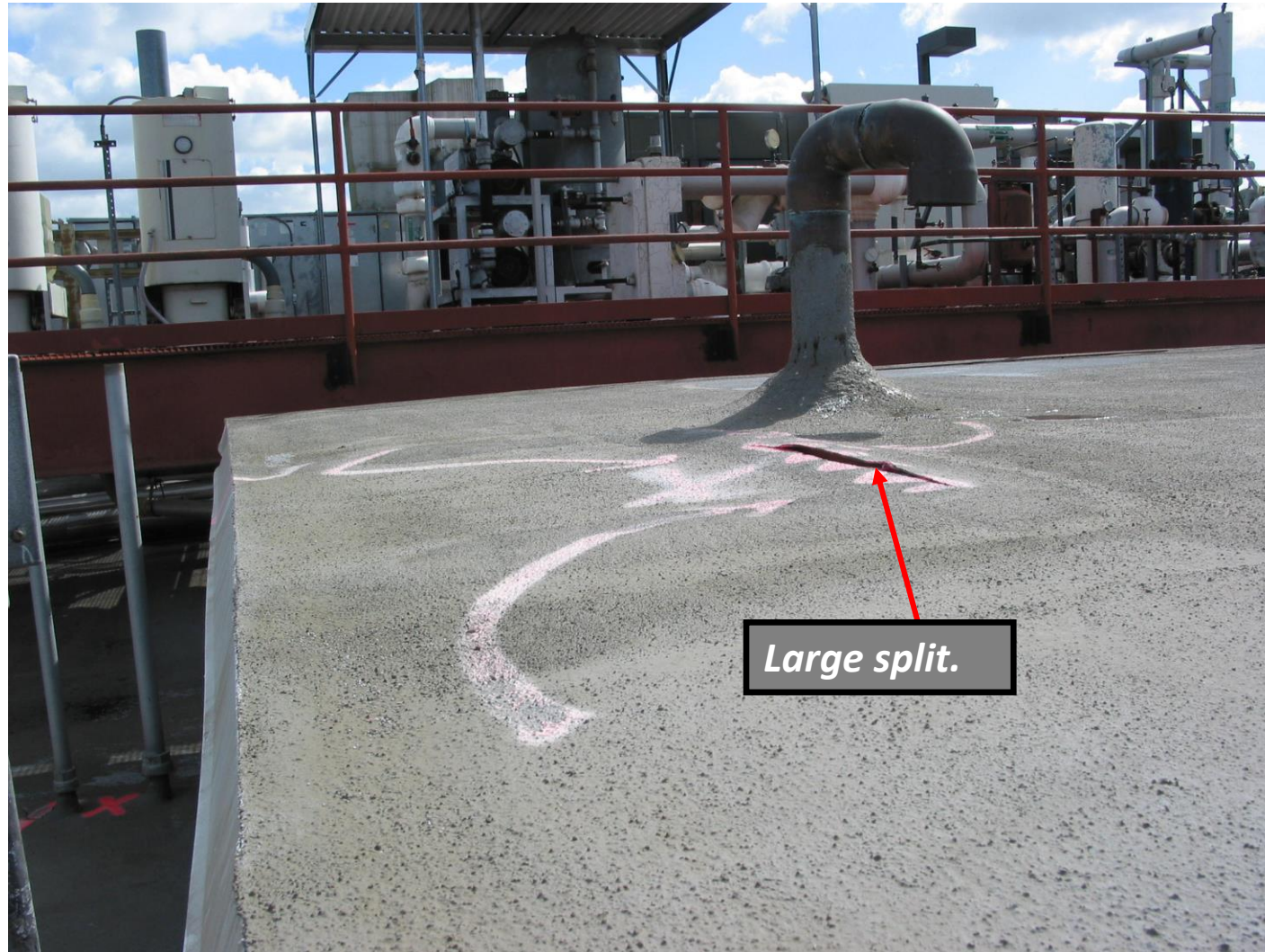
# Foam Roof Failure

*Foam Roofing on an industrial Building = bad idea*



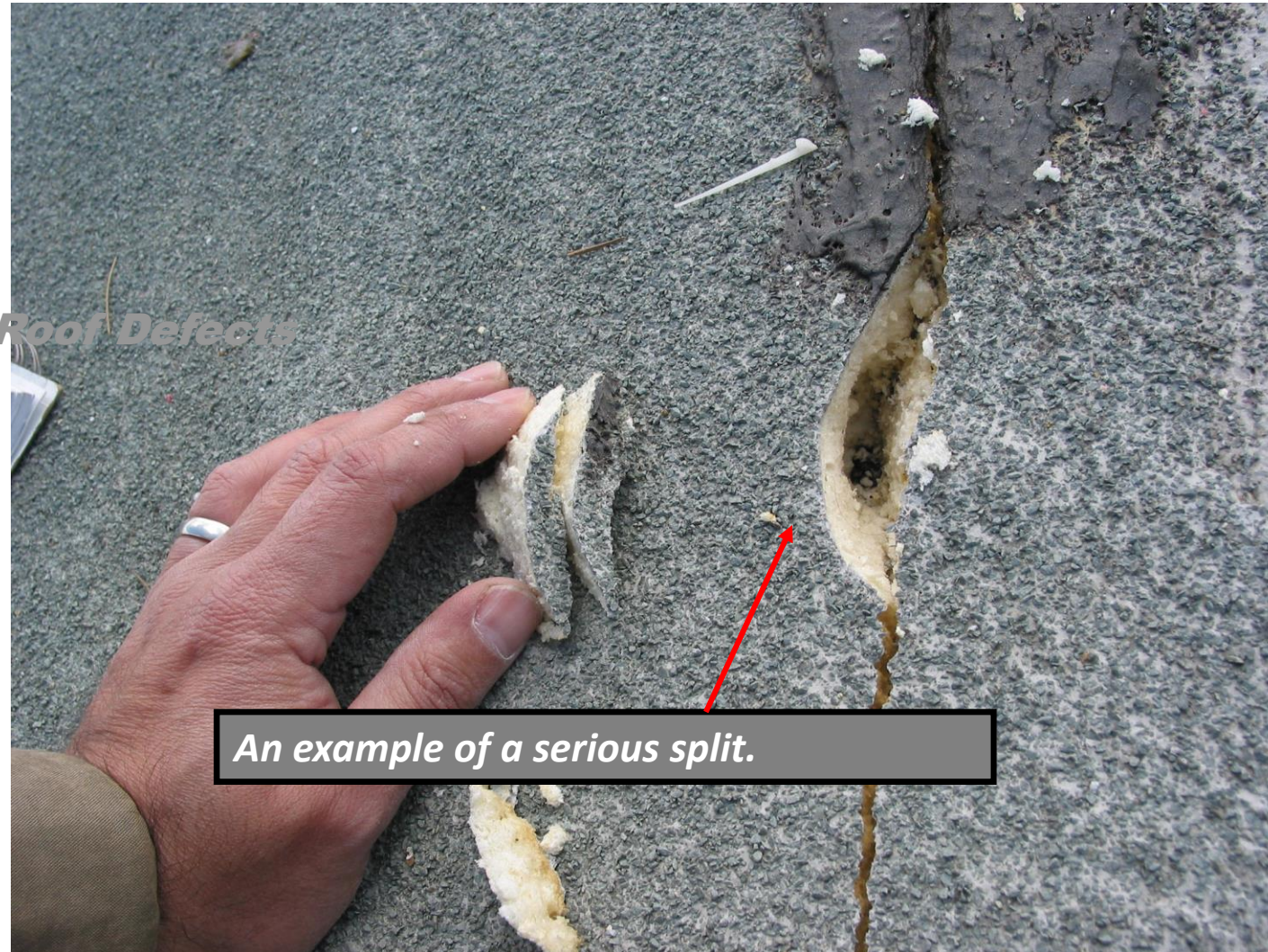


# Foam roof with Polyurea+Silicone Coating





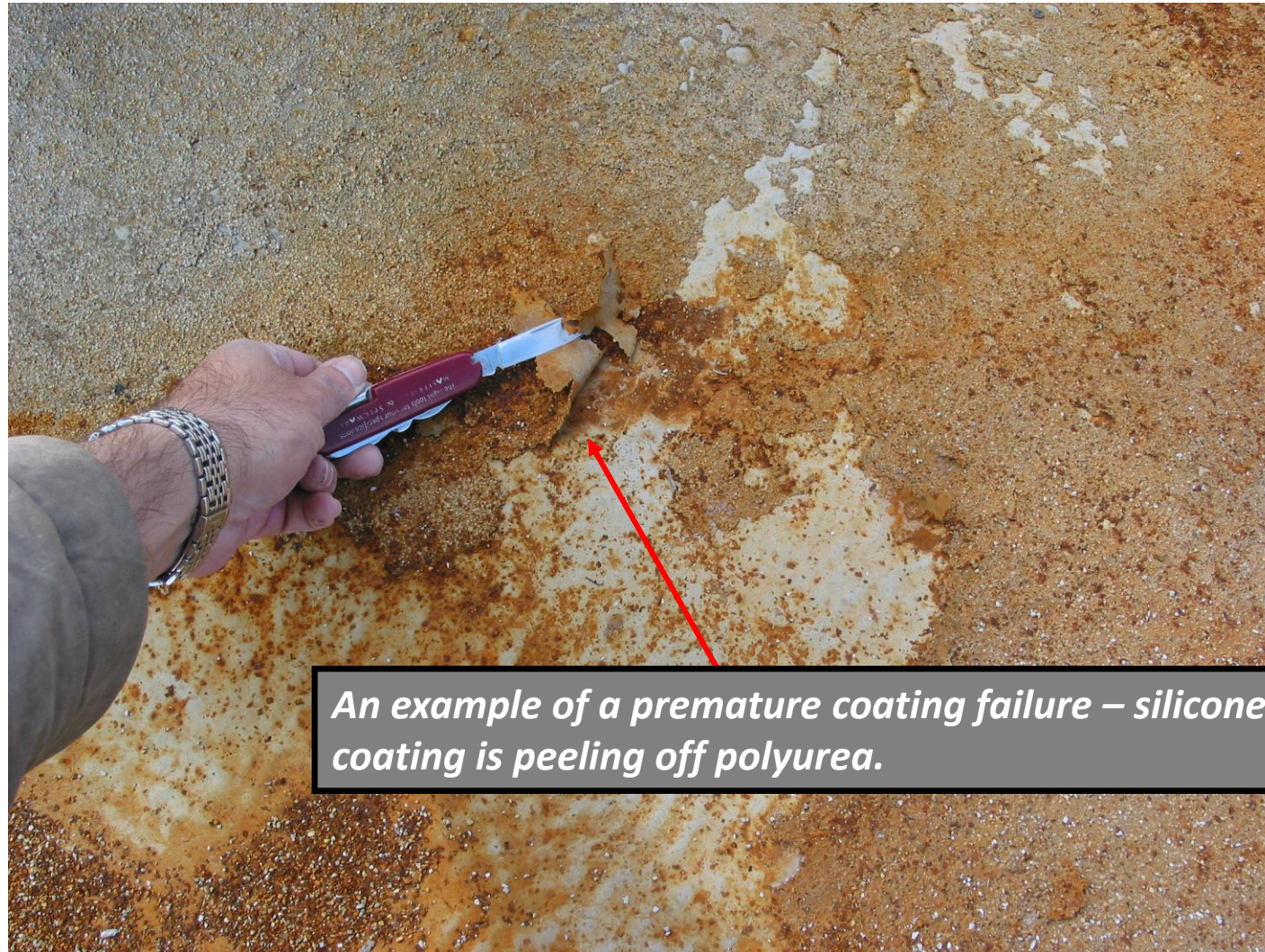
# Polyurea Coating, Long Term Shrinkage



*An example of a serious split.*



# Roof Defects



*An example of a premature coating failure – silicone coating is peeling off polyurea.*



# Roof Defects



*Coating is delaminating due to application over foam overspray, which has oxidized.*



# Roof Defects

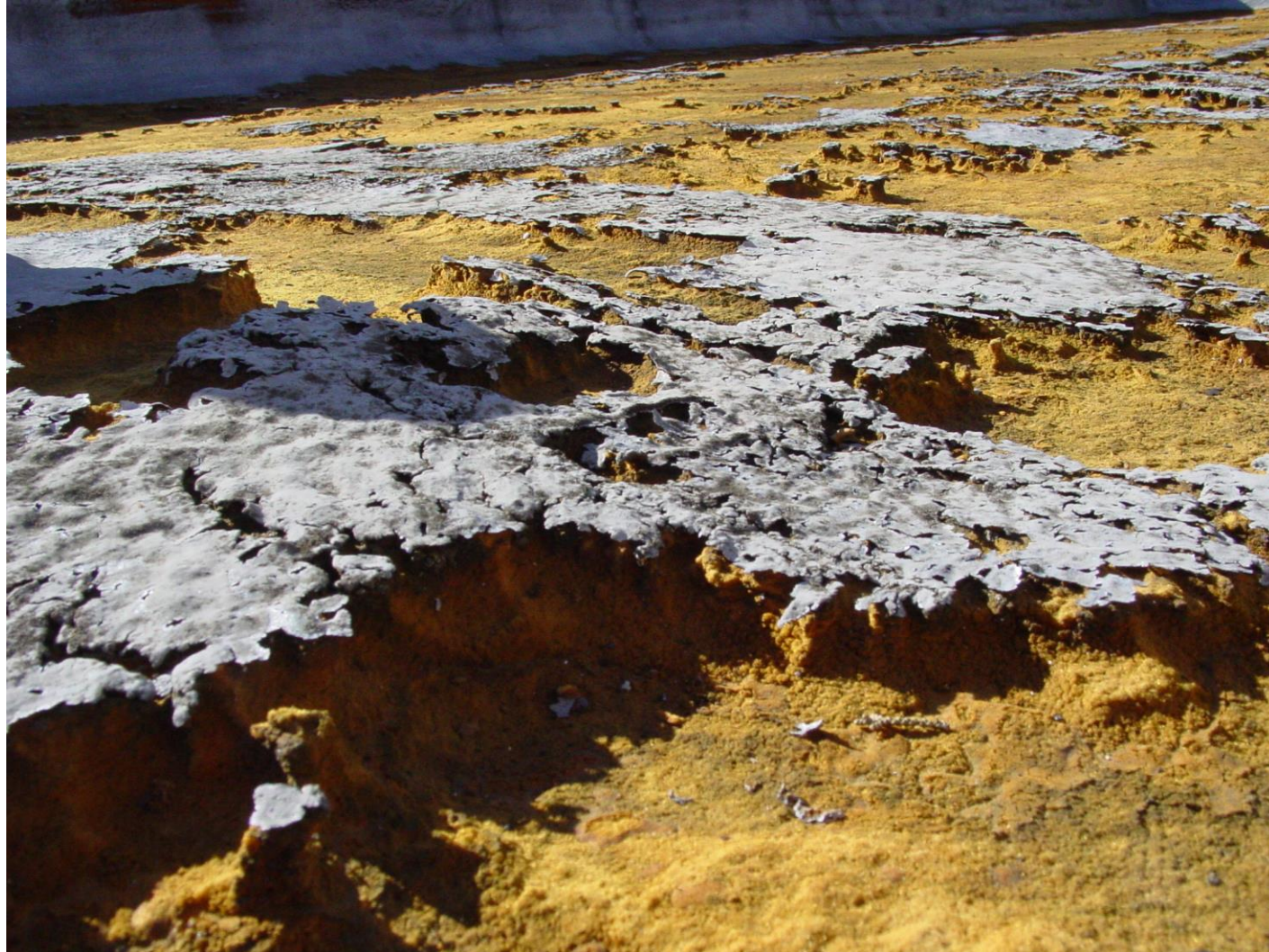


# Foam roof did not receive re-coating in time





# UV degradation of foam due to loss of coating





# Tile Roofs



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# Tile Roofing Clay Tile



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# Case Overview

- Construction defect litigation case in Northern California.
- Seven (7) year old concrete tile roof.
- Many leaks visible below, in living areas.
- Visible cracks in tile.
- There were some conditions of concern:
  - Tile layout.
  - Roof to wall conditions.
  - Valley flashing.
- Asked to investigate the source of leaks.



# Tile Roof Failure





*Significant leaks in ceilings*



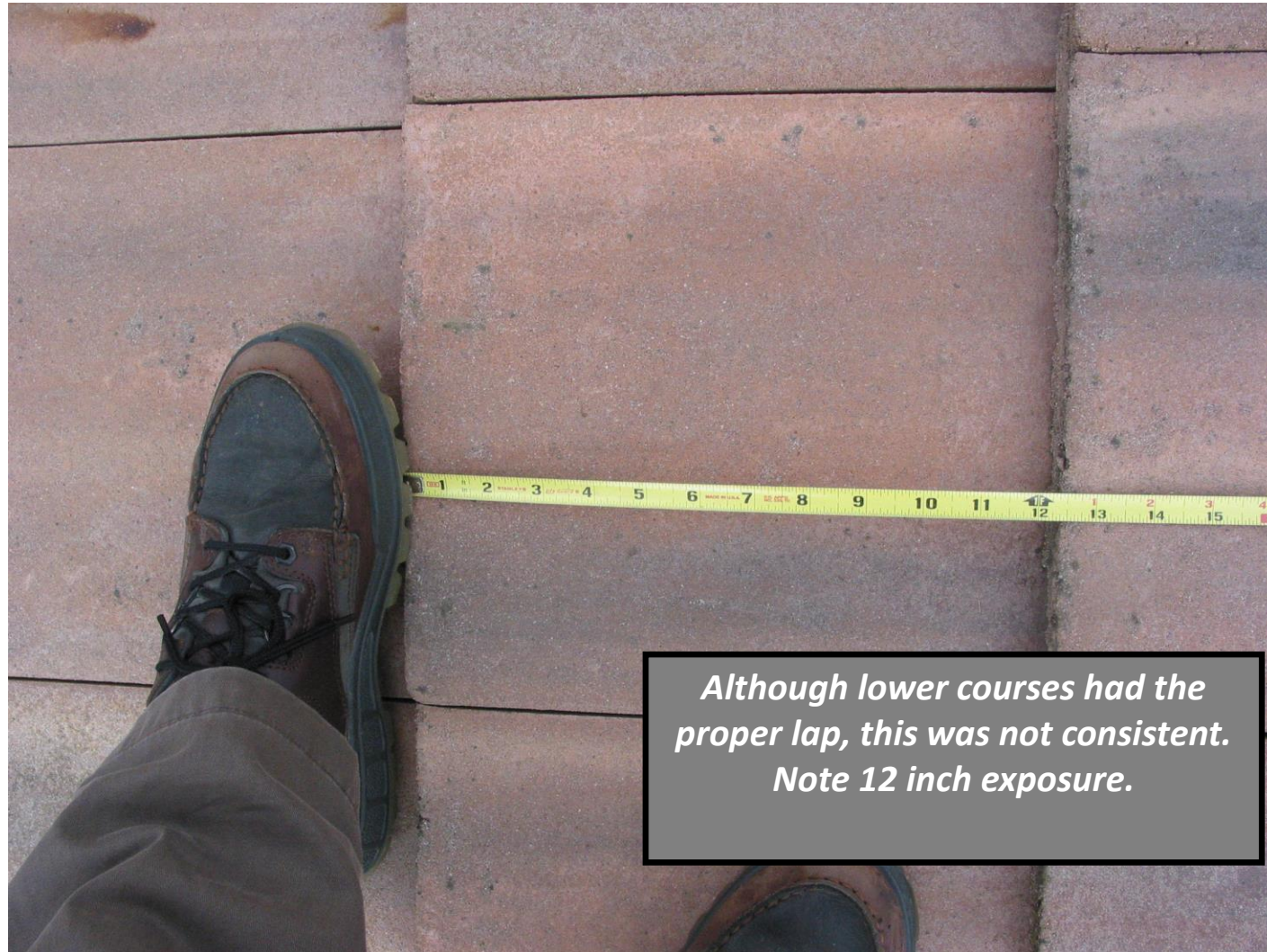


*Distressed conditions*

# Forensic Methodology

- Review of plans and specifications.
- Visual inspection.
- Compliance with Manufacturer's published literature.
- Code compliance investigation.
- Water testing.
- Destructive testing.
- Preparation of a defect report.

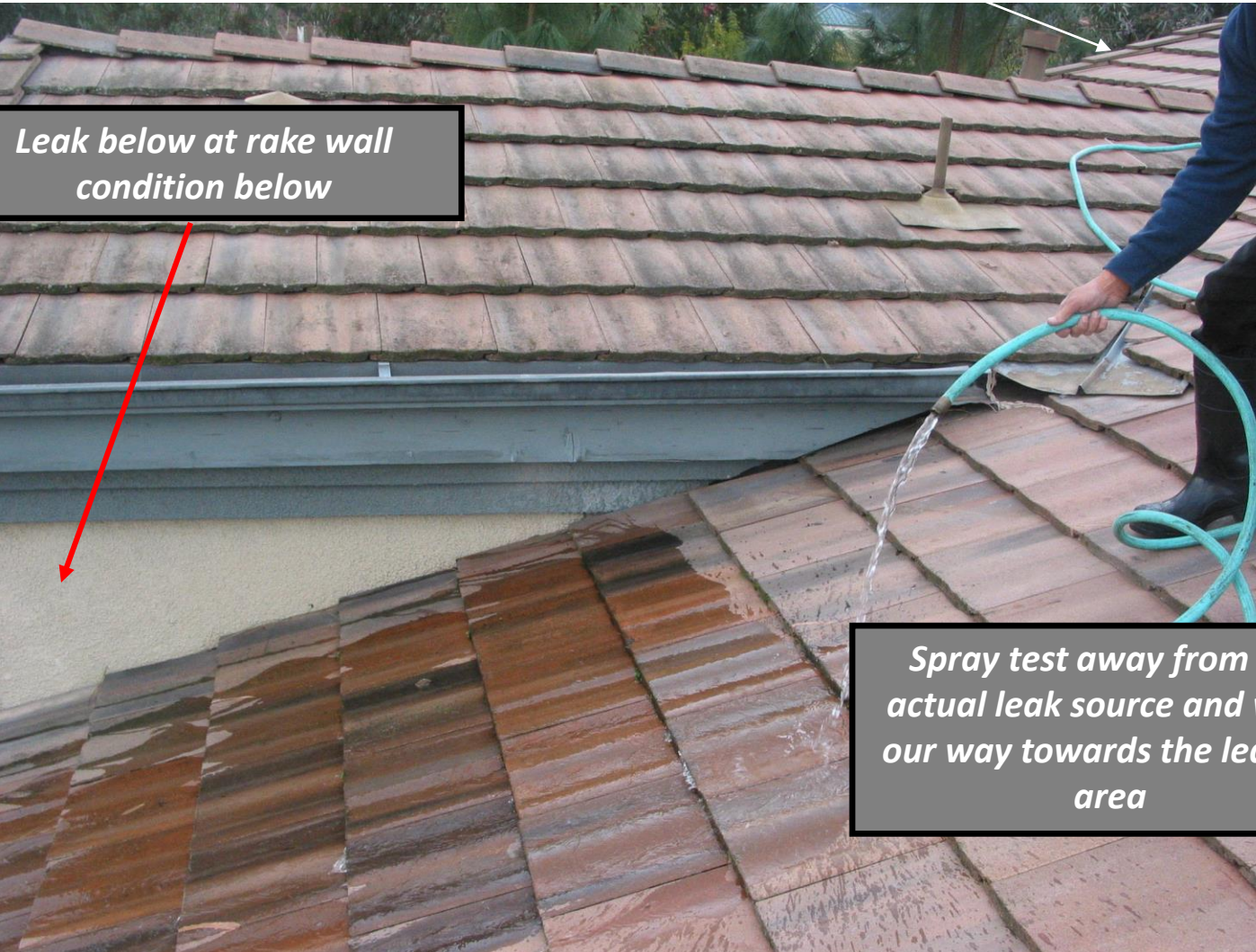












*Leak below at rake wall  
condition below*

*Spray test away from the  
actual leak source and work  
our way towards the leaking  
area*





*Let the water run down the  
confined rake condition –  
no leak!*





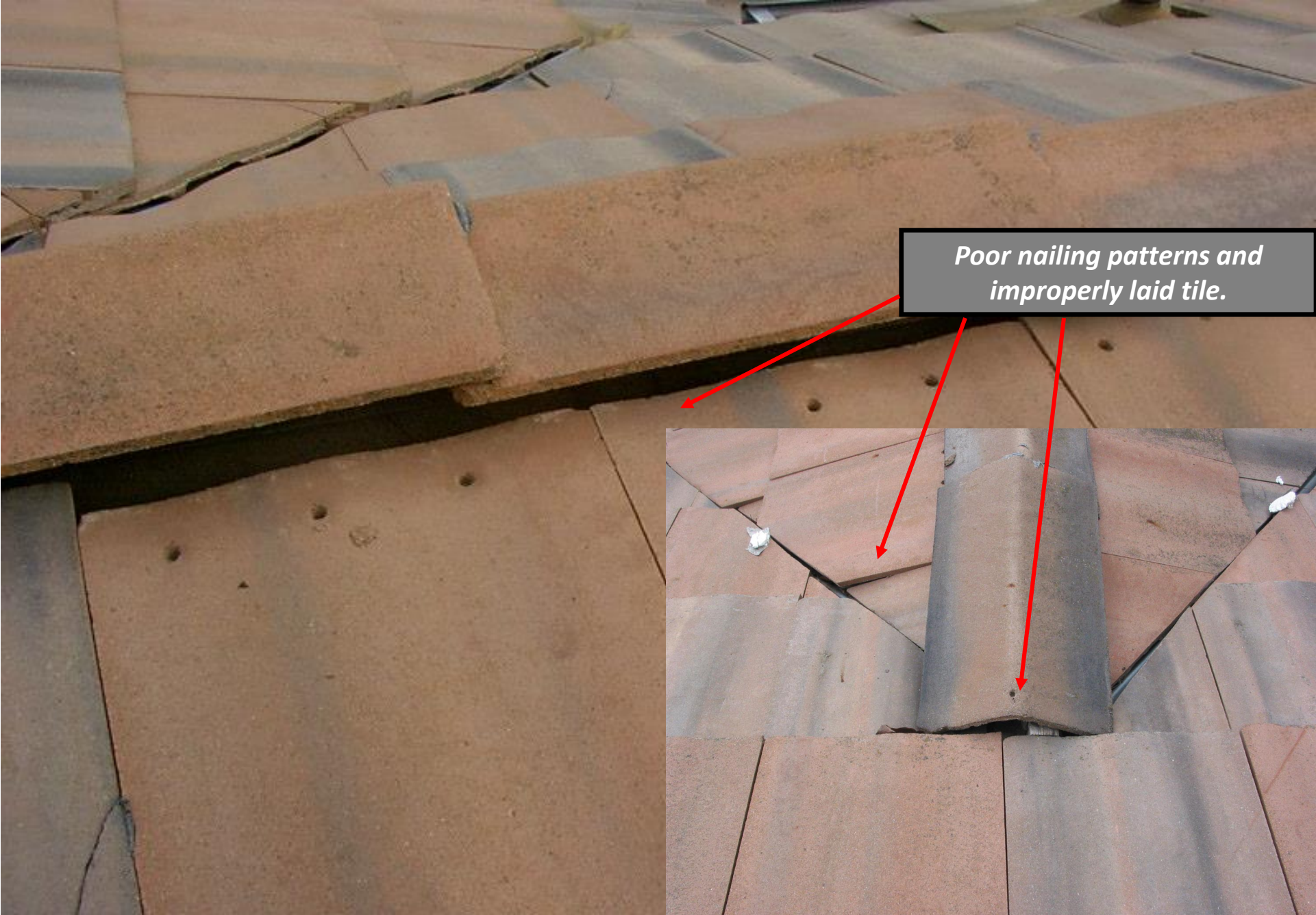
*Water tested the gable roof area above the confined rake.*



Improper membrane was utilized as wind block. 30 lb felt was used instead of 9 inch pressure sensitive adhesive membrane recommended by material manufacturer. But, this was not the primary source of leak in unit below.







*Poor nailing patterns and  
improperly laid tile.*



*Roof cement covers nails, but  
nails must not be exposed.  
Ridge tile is not lapped  
properly.*













*Much of the tile was installed with staggered joints. We observed a very high incidence of broken tile corners.*





*Some roofs had tile laid in straight bond method, which had fewer broken tiles but instinctively seemed wrong.*



- What is the correct way to install this tile, broken bond or straight bond?

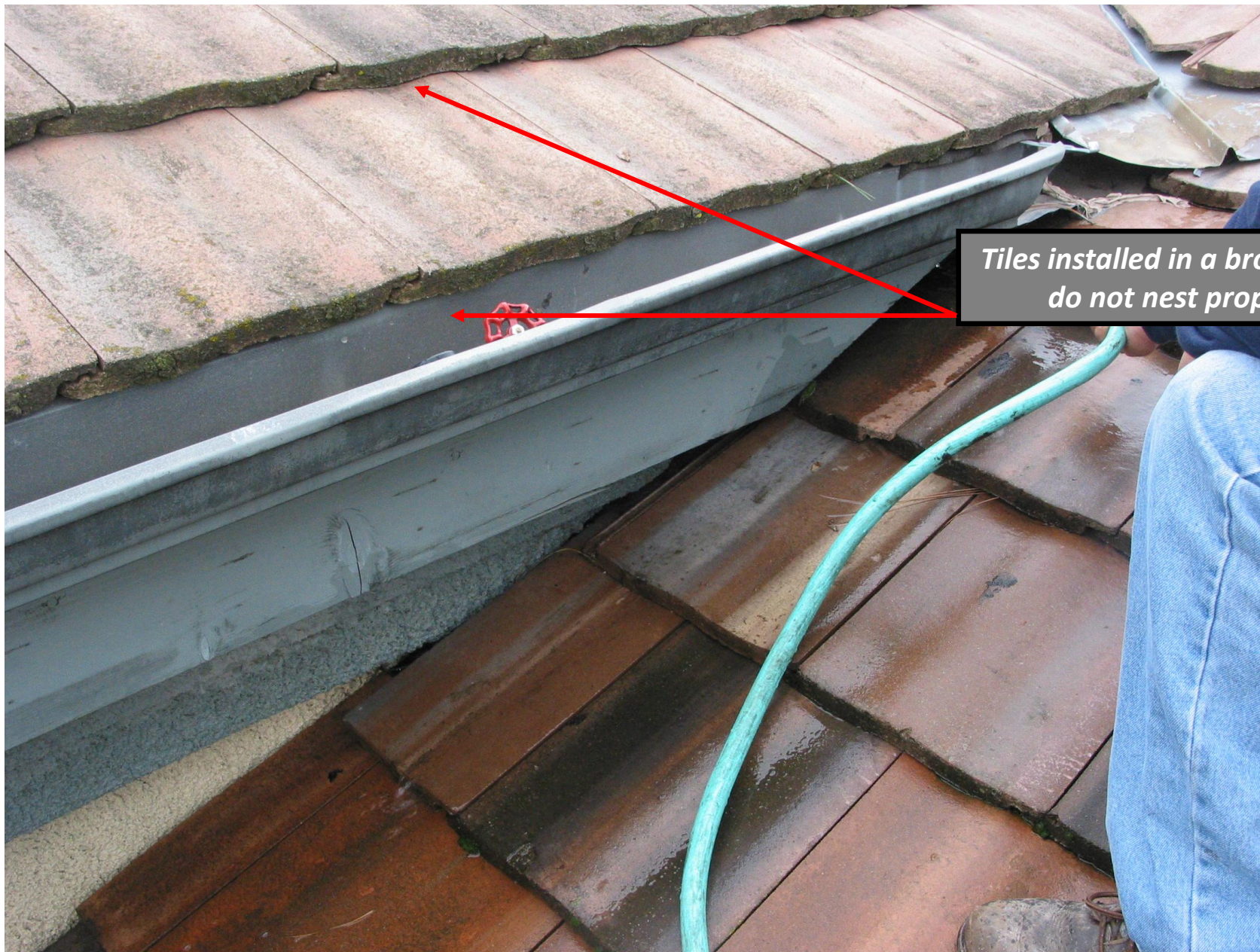


# ANSWER: The manufacturer of this time recommends the straight bond method.



*Joints in tile not parallel  
and are too close, resulting  
in breakage*





# Analysis of Leak Testing

- We knew water was leaking under the tile at broken tile corners.
- The amount of water leakage had deteriorated the felt underlayment.
- We knew the ridge was also contributing to some leakage.
- Approximately half the roof was installed in a straight bond and other half was installed in a running bond pattern.





*Chimney cricket flashing solder joints broken, sealed with mastic.*











*Battens were too short, causing tiles to fall in wrong direction*







*Rotted felt underlayment*









# Lessons Learned

- Tiles, even in the best of conditions, shed only 95% of water.
- Failure of flashings, layout and other problems, drop that to 80%.
- Lack of proper details creates significant leaks.
- Ignore manufacturer recommendations at your own risk!!
- Basic design was lacking – flashing and other problems.
- Installation was not closely monitored for consistency.



# Tile Roofing Concrete



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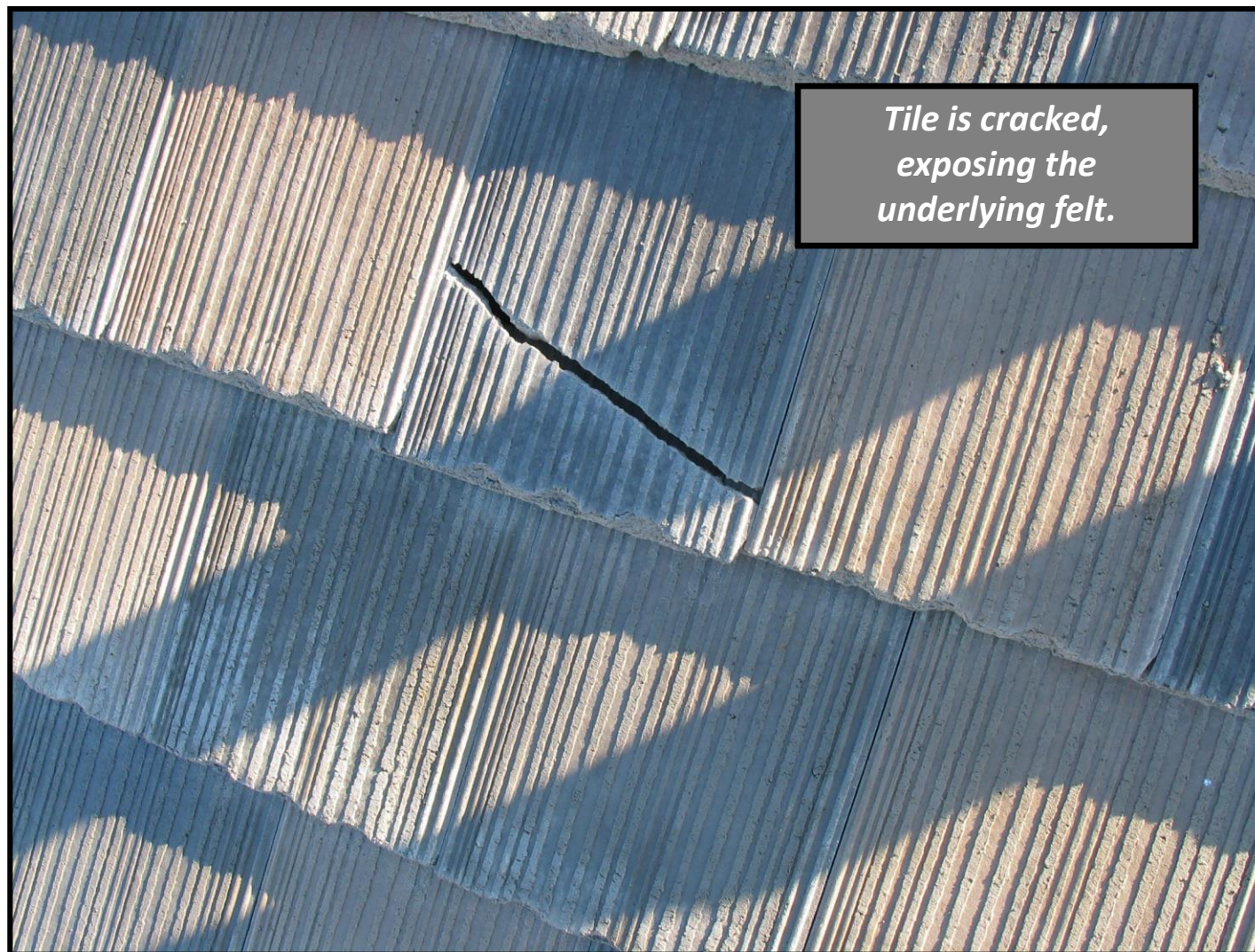
# Case Study: *Concrete Tile*

- Construction defect litigation case for a REIT in Northern California.
- 4 year old concrete tile roof.
- Visible cracks in tile.
- There were some conditions of concern:
  - Tile layout
  - Roof to wall conditions, especially at rakes
  - Flashing installation
- We were asked to investigate the source of leaks on behalf of the new owner.

# Forensic Methodology

- Similar to the other concrete tile case.
- Preparation of a defect report.
- Negotiation with the seller.





*Tile is cracked,  
exposing the  
underlying felt.*

















*Vertical depth of  
flashing leg is too  
short, only ½ inch.*





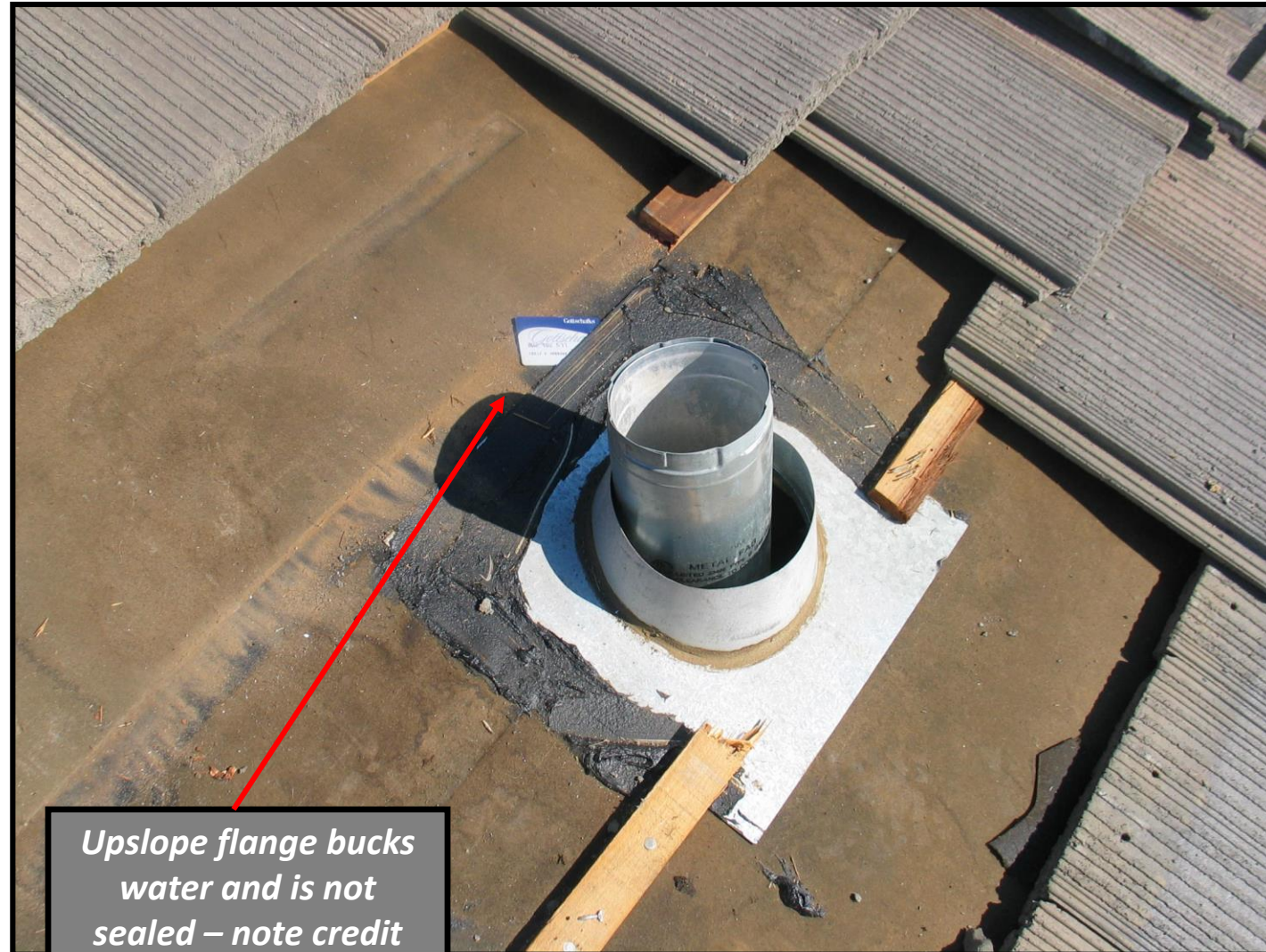
Width of valley metal is 20-1/4 inches.





Cut tiles are loose  
laid in the valley.





*Upslope flange bucks water and is not sealed – note credit card in joint.*





*Tile manufacturer  
requires a full bead of  
roofers mastic at hip  
tile overlaps.*

*Red line indicates how  
the mastic should have  
been installed.*



# Roof Coatings



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# Roof Coatings

## Extending the life of roofs with acrylic coatings



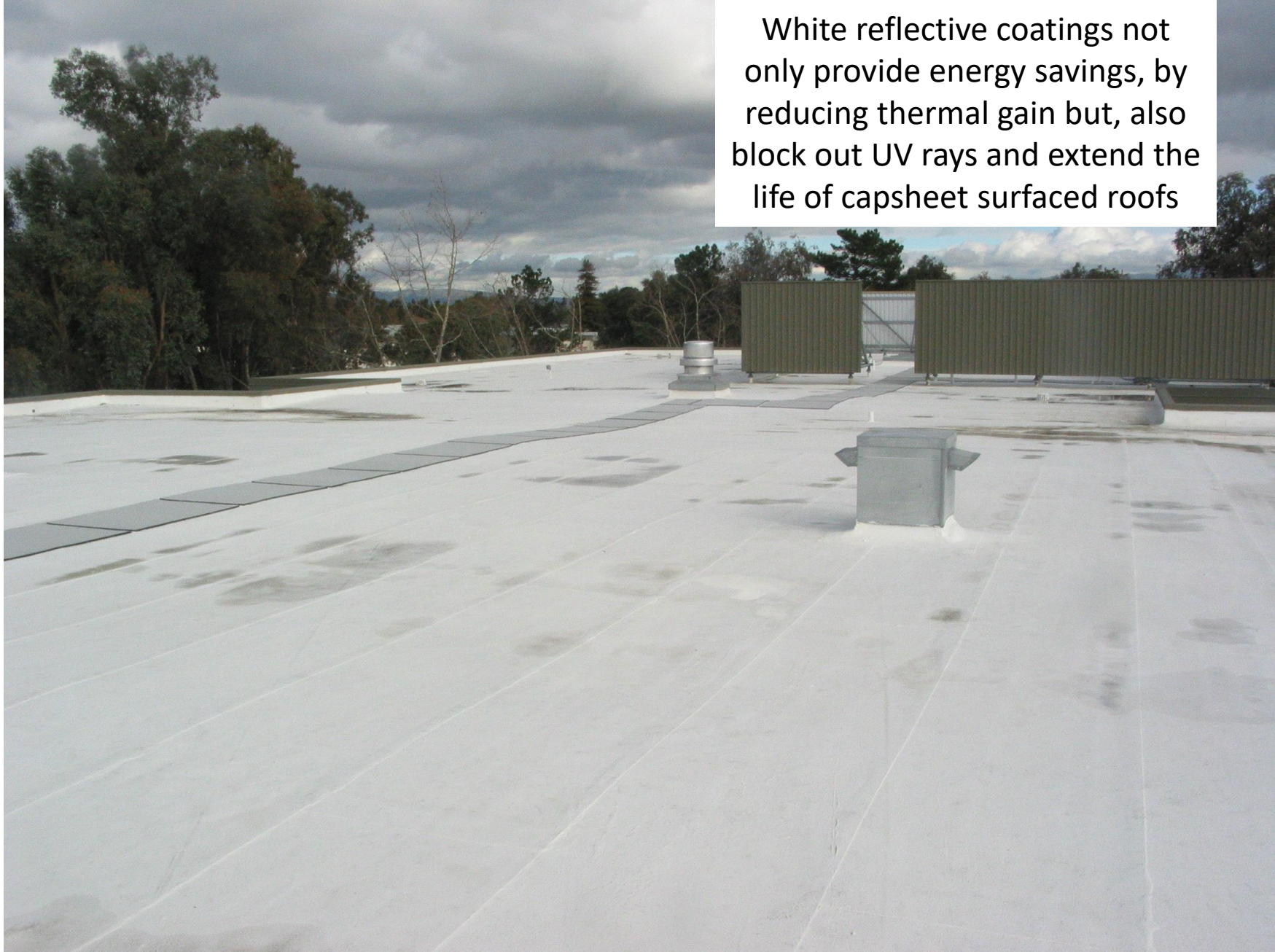
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Properly installed cap-sheet roofs have a life expectancy of 15 to 25 years, depending on number of plies.





White reflective coatings not only provide energy savings, by reducing thermal gain but, also block out UV rays and extend the life of capsheet surfaced roofs



- Properly applied white reflective coating can potentially double the life of a capsheet surfaced roof due to the added UV barrier







# Roof Coatings

# Roof Coatings Over Metal

# Roofs



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- Acrylic coatings can also extend the life of low sloped metal roofs

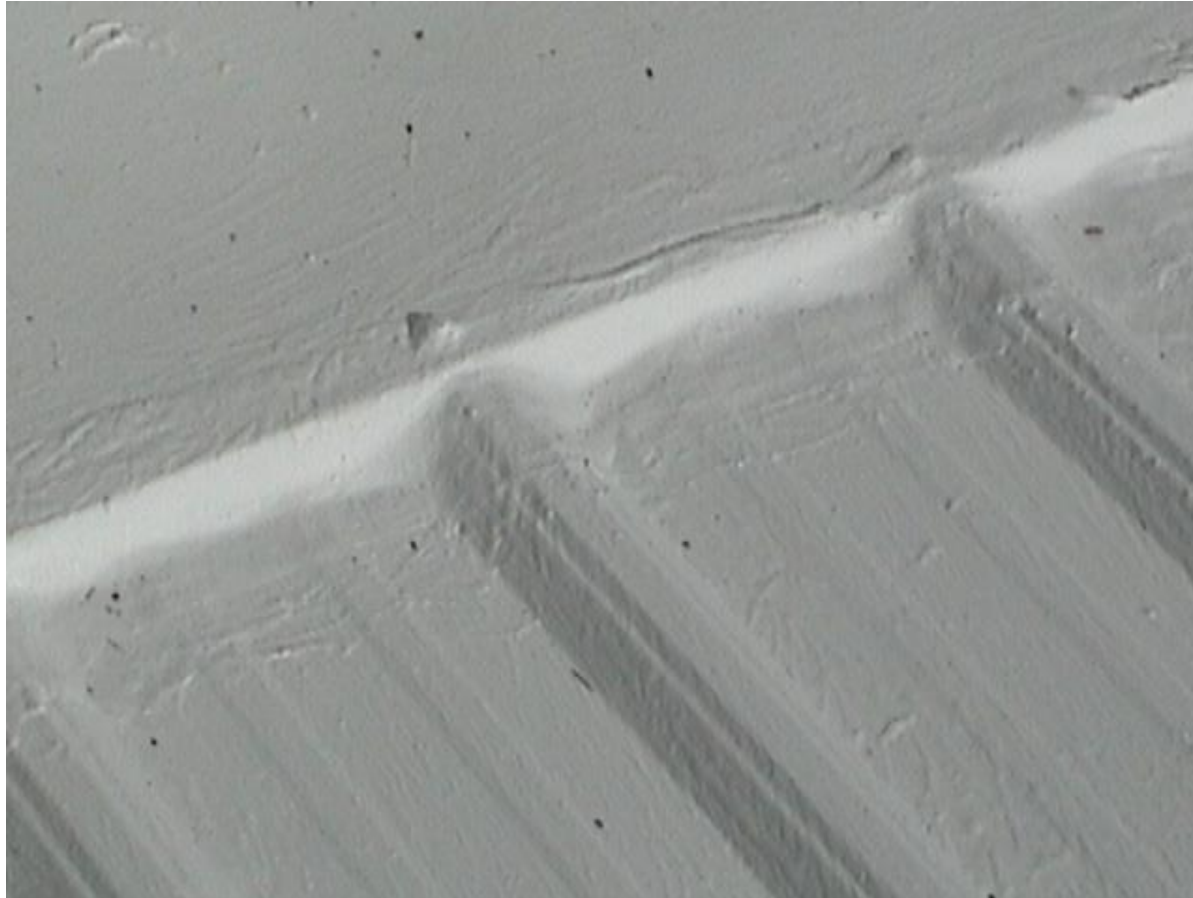




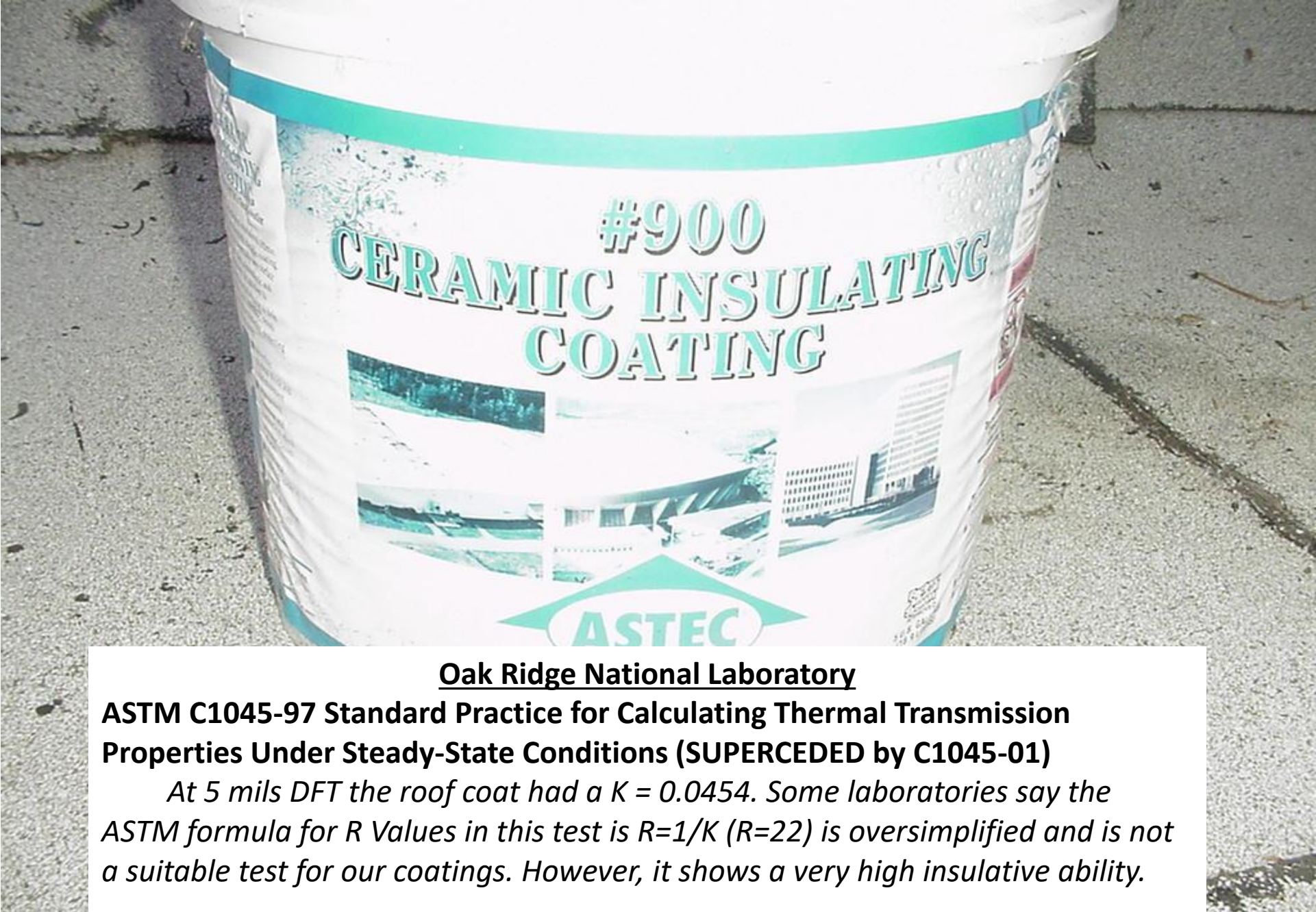
# Restoration of low sloped metal roof



- Acrylic coating over metal are not aesthetically great.
- Coatings and reinforcement seal exposed fasteners







**Oak Ridge National Laboratory**

**ASTM C1045-97 Standard Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions (SUPERCEDED by C1045-01)**

*At 5 mils DFT the roof coat had a  $K = 0.0454$ . Some laboratories say the ASTM formula for R Values in this test is  $R=1/K$  ( $R=22$ ) is oversimplified and is not a suitable test for our coatings. However, it shows a very high insulative ability.*



# Single Ply Roofing PVC



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# Case Overview: *Department Store*

- Large department store in Northern California.
- Eighteen years old.
- No repairs, no leaks, no problem?
- Purpose of the investigation: Determine longevity of single ply.
- We were with a team of other skeptical consultants.

*Example of roof installed in 1983,  
inspected in 2001.*





# Forensic Methodology

- Visual inspection to observe performance of system for sustainability.
- Limited destructive testing.
- Laboratory testing of samples to compare between original membrane and aged membrane.

# Sustainability Checklist

- Roof system's ability to handle foot traffic and impact damage.
- Membrane's ability to handle ponding water and condensate.
- Membrane's ability to be patched and repaired.
- Membrane's physical properties, tensile strength, thickness, bend test, etc.



# Sustainability Checklist (con't)

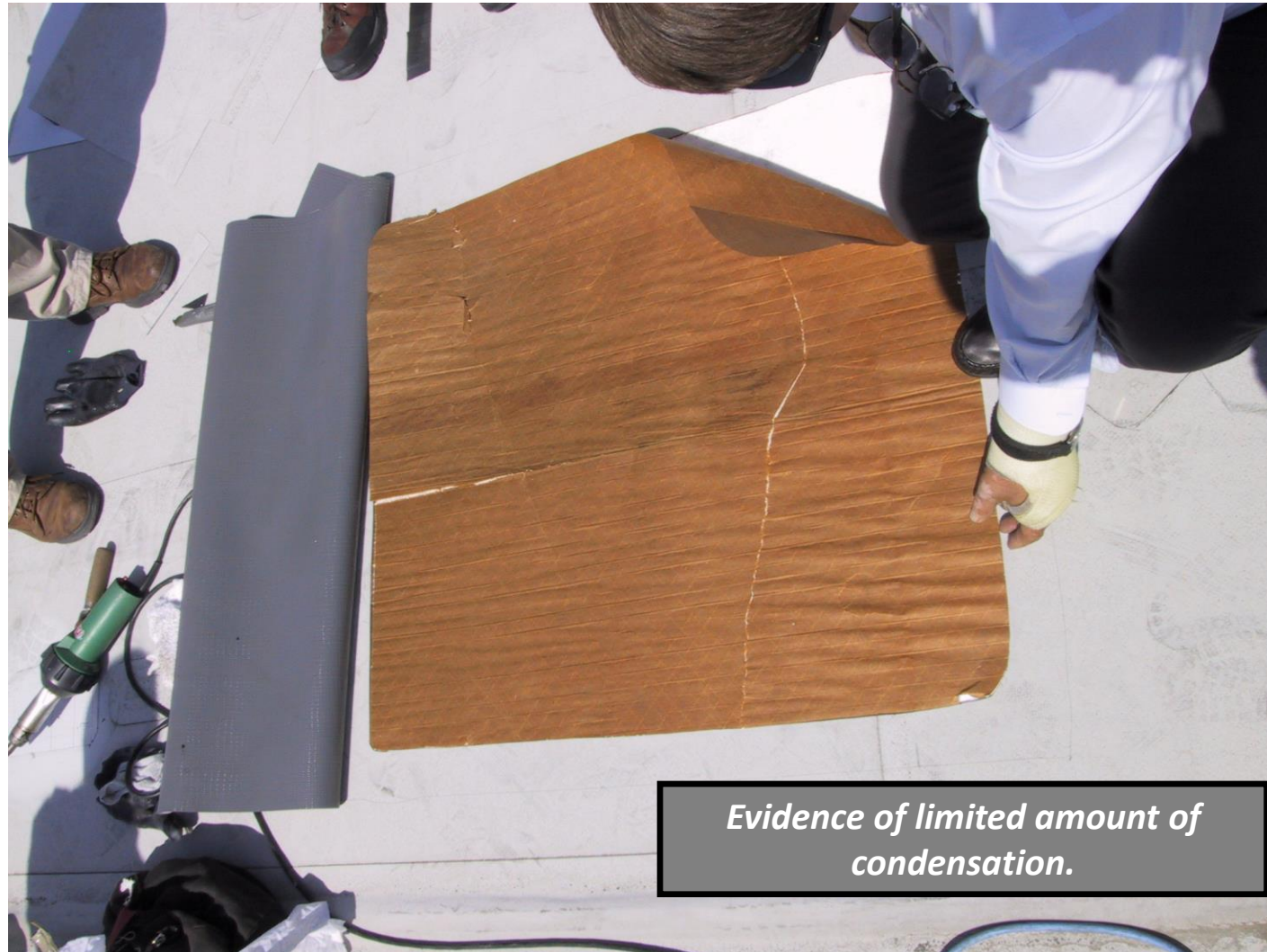
- Was roof system sustainable for type of use (retail store)?
- Was original design of the roof system adequate for its intended use?
- Was original application (construction) installed per manufacturer's requirements?

# Test Cut Analysis

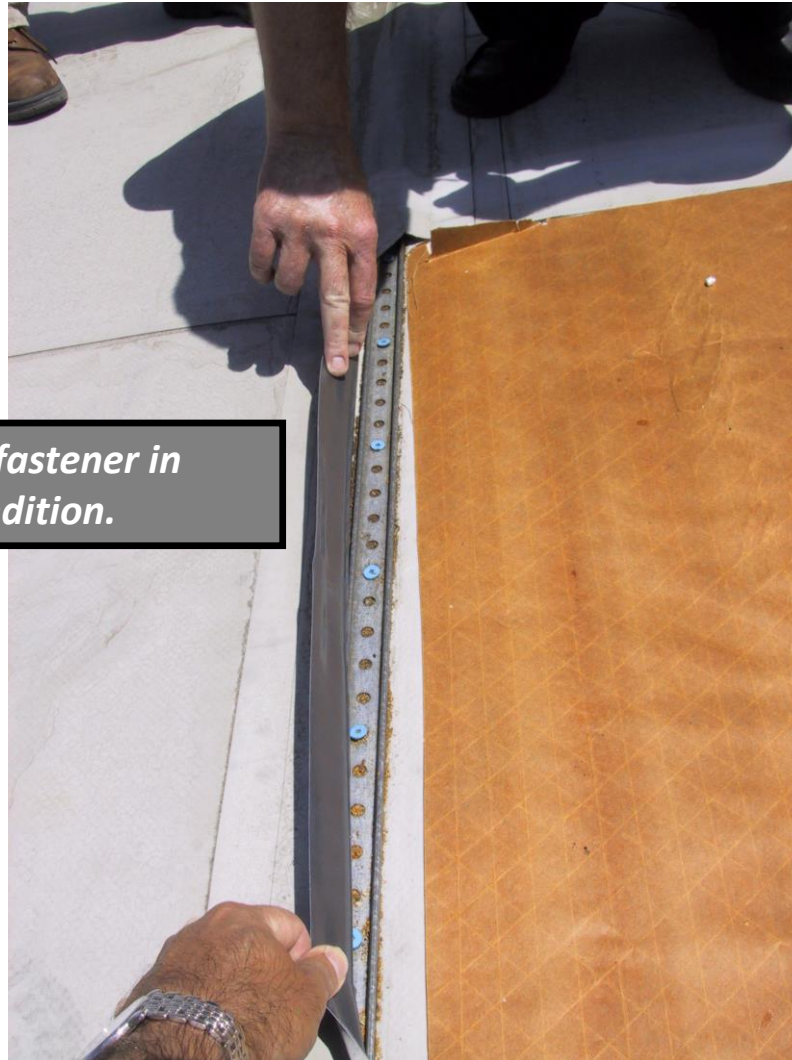
*Test cut exposing rosin paper and insulation.*







*Mechanical bar fastener in  
excellent condition.*







*Membrane patching was no problem.*

# Visual Analysis



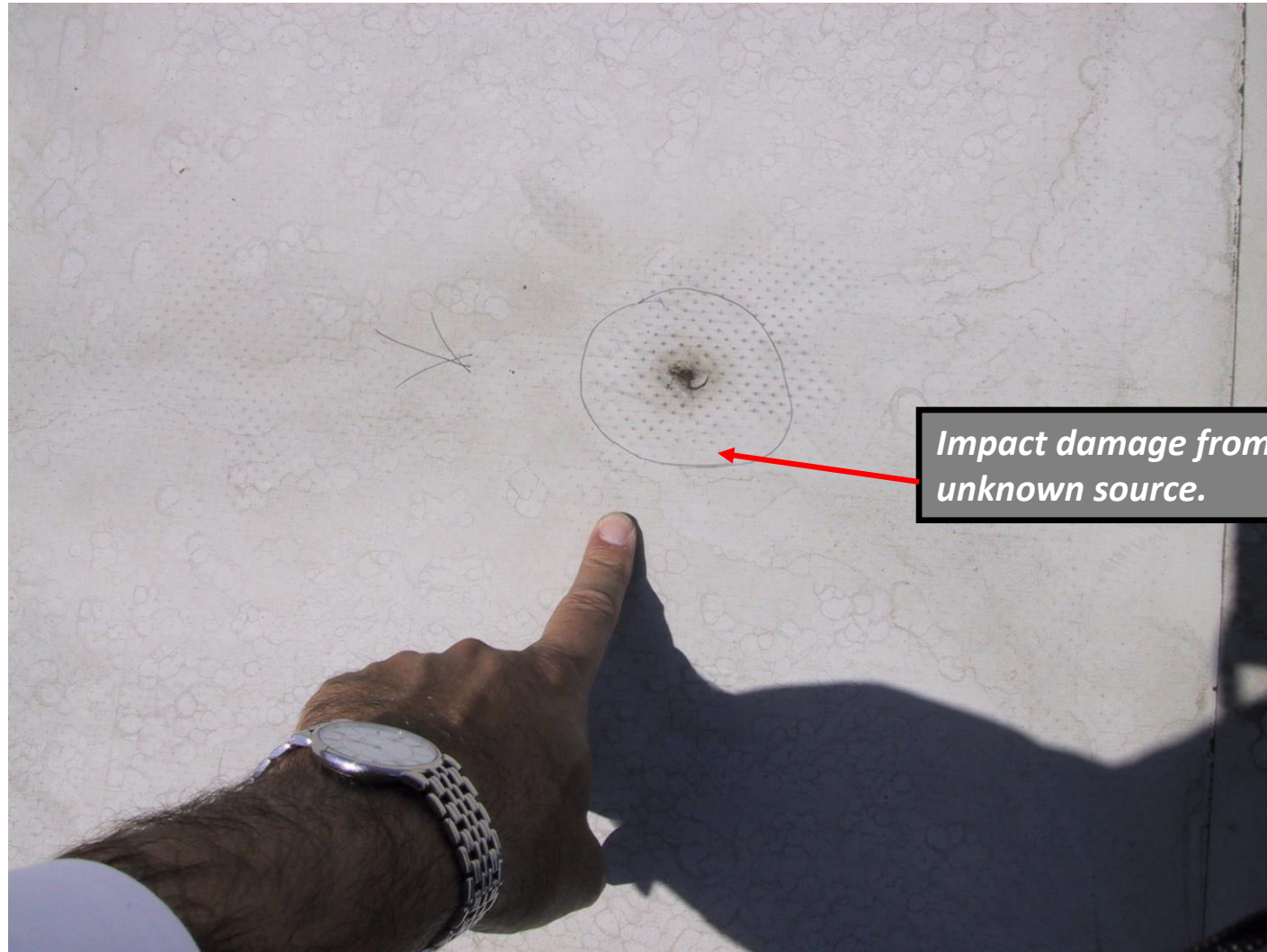
*Construction debris was observed on roof.*



# Design Issue



*Equipment supports not integrated and secured into roof. Design of pipe supports not sustainable.*



*Impact damage from  
unknown source.*





Evidence of nail from  
construction debris.





Sustainability, impact damage.

*Membrane damage from  
unknown source.*



# Tenant Improvement Work



New electrical pipe added, pipe jack set in mastic (not properly flashed with single ply) and wood block set in mastic (incompatible with PVC).

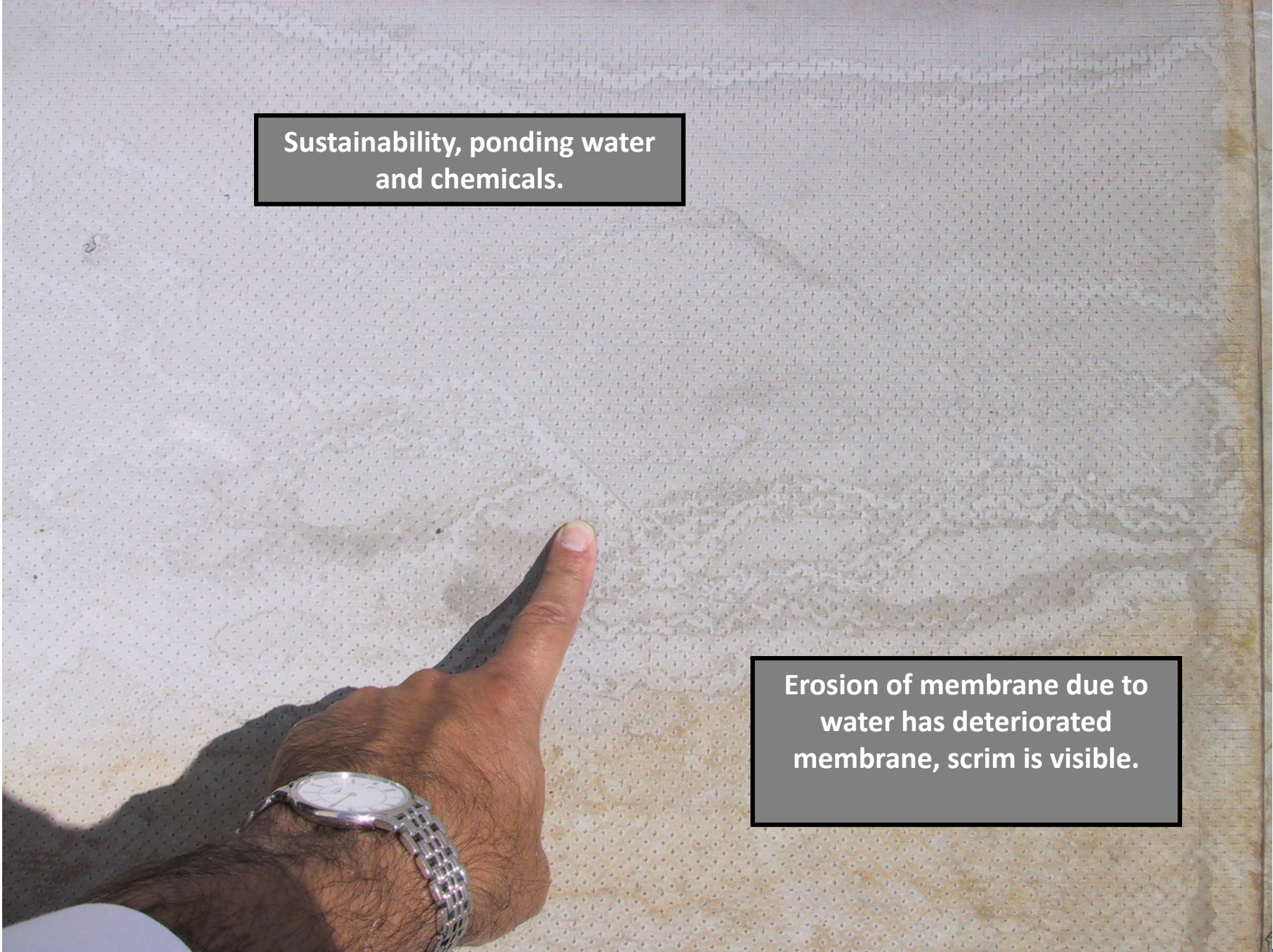




Cooling tower and  
condensate water leaking  
over roof.







Sustainability, ponding water  
and chemicals.

Erosion of membrane due to  
water has deteriorated  
membrane, scrim is visible.



# Laboratory Test of this 18 year old single ply

- Samples tested for thickness
- Tensile strength
- Shrinkage and dimensional change
- Seam strength
- 95%+ samples met original membrane test results

# Sustainability Score

- MEMBRANE MATERIAL
  - Field areas of membrane performance good/excellent 20+ years
  - Easy to patch
- TRAFFIC AND IMPACT DAMAGE
  - Susceptible from impact damage
  - Damage easy to identify and repair



# Sustainability Score

- DESIGN
  - Original poor design of pipe supports caused damage
  - Poor design of roof drainage caused ponding water and damage
  - Poor design of condensation control mechanism caused damage

# Sustainability Score

- MAINTENANCE

- Lack of frequent inspection
- Lack of proper roof protection during remodel construction
- Lack of proper maintenance of HVAC equipment damaged the roof
- New pipe penetrations not properly flashed (use of asphalt mastic)



# Lessons Learned (Single Ply)

- Sustainability depends on many factors.
- Membrane's ability to handle normal exposure to sun, rain and elements.
- In 20+ years, expect the roof to go through many different challenges.
- When designing a roof, consider, building may undergo remodel, HVAC replacement, new electrical addition, etc.
- Impact of original design defects.
- Owner's lack of frequent inspections, timely repairs, and use of proper patching techniques.



# Roofing Issues



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# LEGAL ISSUES TO CONSIDER

- This section will include the following:
  - Maintenance vs. Repairs
  - Life expectancies
  - Express & Implied Warranties
  - Design-Build Role of a contractor
  - Statue of Limitations for defects/leak
  - How insurance pays for leak damage

# Maintenance Vs. Repairs

- ✓ Inherent construction defects, requiring repairs, are not regular maintenance!
- ✓ Construction defects are the responsibility of the builder/contractor
- ✓ Properly designed and installed roof generally require very limited maintenance.
- ✓ Know what falls outside of regular maintenance



# In Order To Define What is Maintenance and What is a Defect

- Define life expectancy of roofing, sealants, windows, walls, waterproofing, painting, etc.
- Define what is maintenance and what is repair
- Leaks and repair of roofing, sealants, waterproofing, building exteriors, windows, within 10 years of completion = construction defect.

# Life Expectancies...

- Sealants: 10 to 25 years
- Roofs: 10 to 40 years
- Below grade waterproofing: Life of the building
- Windows: Life of the building
- Window gaskets: 10 to 20 years
- Stucco: Life of the building
- Painting: 5 to 7 years
- Wood siding: 50 to 100 years



# Owner Responsibility for Ongoing Maintenance

- Frequently Occurring Items Like:
  - Gutter cleaning.
  - Debris cleaning.
  - Annual inspection of roofs, sealants, windows, walls and exterior façade.
  - Tree trimming.
  - Low pressure power washing of roof and exteriors of building.

# Owner Responsibility for Repairs on Occurrence

- Damage from trees and roots.
- Damage from cars and foot traffic.
- Damage from vandalism or abuse.
- Severe storm, earthquake, hail, hurricane, and other natural phenomena.
- Damage from oil and chemicals.



# Defect – Not Maintenance

- Pipe jacks needing mastic repair because they are leaking
- Scupper needing repair due to failed solder joint
- Plies delaminating from edge flashing
- Mastic loose seams of capsheet
- Repair gravel not adhered to roof

# Written warranties, per RCI:

- Warranties can provide peace of mind
- They do not replace :
  - Sound design
  - Good materials
  - Quality workmanship
  - Proper maintenance



# Express Warranty

- Words Warranty & Guarantee are generally interchangeable
- Term of warranty generally stated
- An agreement usually requiring owners signature
- Warranty generally requires that application meets material manufacturer's *published* requirements
- Does not include consequential damage
- May not include overburden cost
- May be limited to materials only
- May depreciate in value over time

# Contractor Responsibility for Defective Construction

- If a 20 year type roofing system needs “repairs” other than true maintenance for repairs.
- If 10 year sealant types need replacement or fail in less than their life expectancy.
- If windows leak in fewer than 10 years.
- If other materials that do not last their normally expected lives, and fail within the first 10 years



# Requirement of Owner, per RCI:

- Provide semi-annual inspection
- Provide roof maintenance
- Report leaks in writing immediately
- Use original contractor for repairs or addition to the roof system
- Keep records of leaks and repairs
- Store all documentation safely

# DESIGN BUILD ROLE OF CONTRACTOR

- In the absence of a licensed architect or engineer of record, Contractor assumes role of Design professional.
- Roofing contractor can be liable for code requirements including leaks, weight of roof, slope requirement, flashing and counterflashing, etc.
- Roofing contractor also has a responsibility to know when to call in a licensed professional



# Statue of Limitation

- Most States allow for a 10 year statue of limitation for defective construction (even re-roofing)
- Most States have a 4 year statue for obvious or “patent” defects
- Most States have a 3 year Statue for hidden or “latent” defects once they become patent.

# Who Pays for Damage From Leaks

- If damage occurs within the statute of limitation, contractor's insurance company is generally liable for costs to fix damage.
- "Completed Operations" portion of the insurance coverage kicks-in.
- Even if contractor goes out of business, insurance company is on the hook.





# MAHALO!



# Single Ply Roofing TPO



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# Oldest TPO Roof in Country (12 years)



# Metal Roofing



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# Metal Roofing Copper



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# Case Overview

- Public library in Northern California.
- Multiple types of roofs 20 year old building.
- Been leaking since original construction.
- In 1997 – Owner's original consultant believed the low sloped roof, gutters and equipment well was leaking.
- Library replaced low sloped roof with single ply, new metal roof over equipment wells and new gutter liners.
- Later, building was gutted in 2003 for remodel and upgrade for new technology.
- Extensive leaks were noticed on the walls, ceilings, along the wall to ceiling connection.
- We were asked to investigate the source of leaks and recommend solutions.



*Roof type: Batten  
metal roof on a  
60,000 square foot  
public library.*



*Single ply roof area is new, was replaced because owners believed it was the primary cause of leaks.*

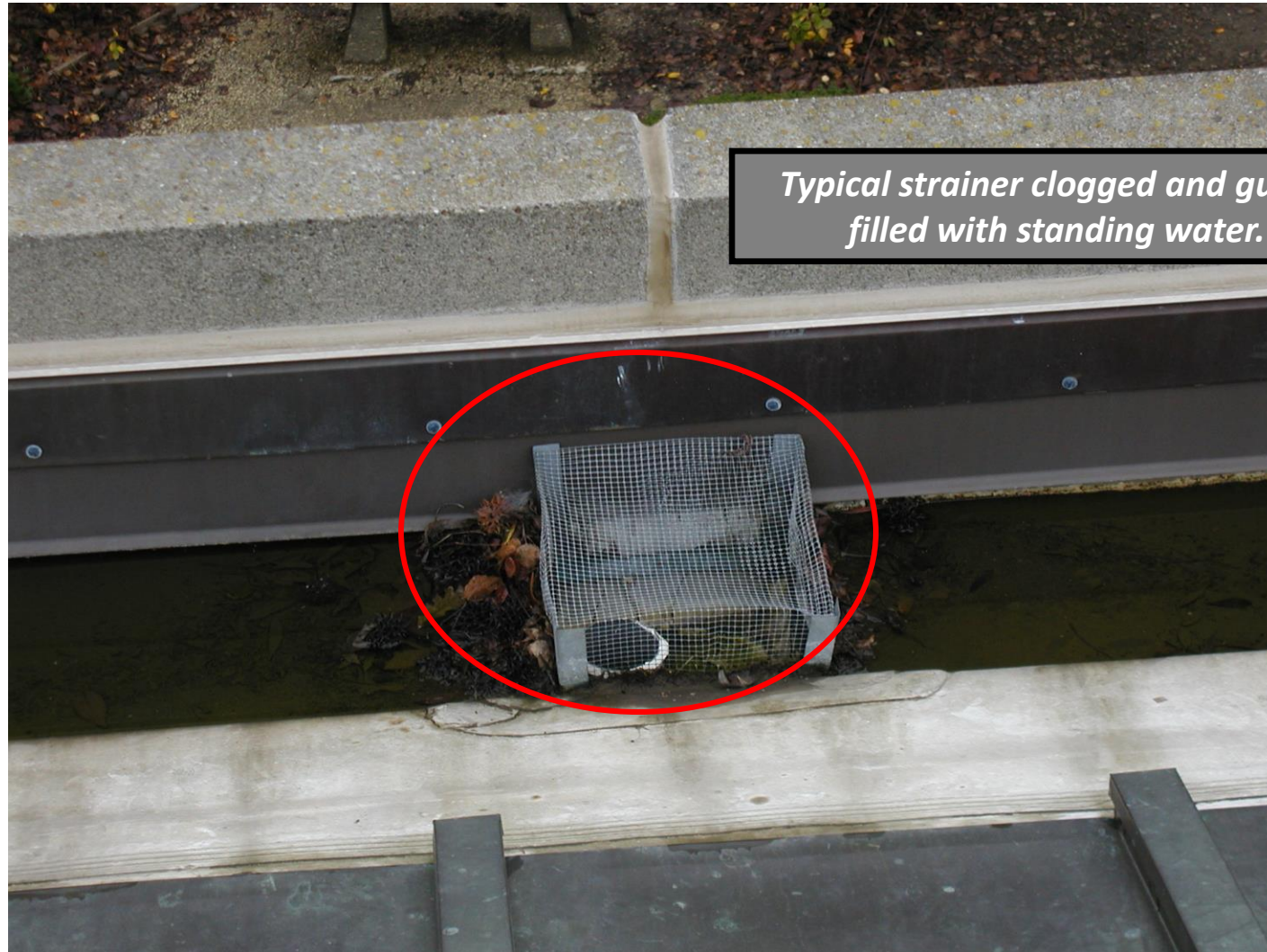
*Equipment well area was also leaking and was covered up with a new metal roof.*







*Extensive ponding, interior gutters restricted debris filled strainers, and ongoing leaks were observed under the gutter despite the 1997 repair.*



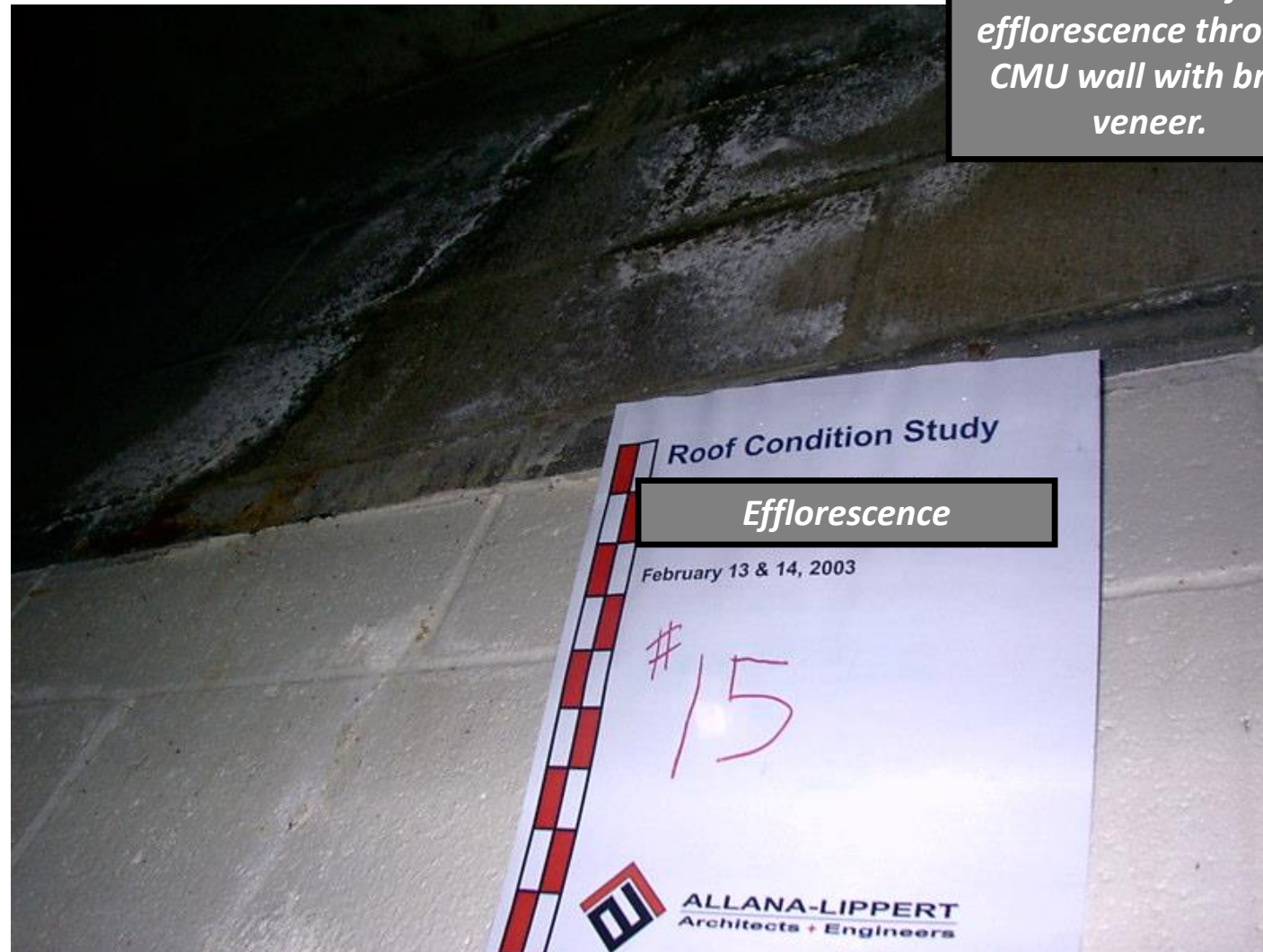
*Typical strainer clogged and gutter filled with standing water.*





*Evidence of significant leaks in the past, below the internal gutters and confined rake wall that already been repaired, once.*

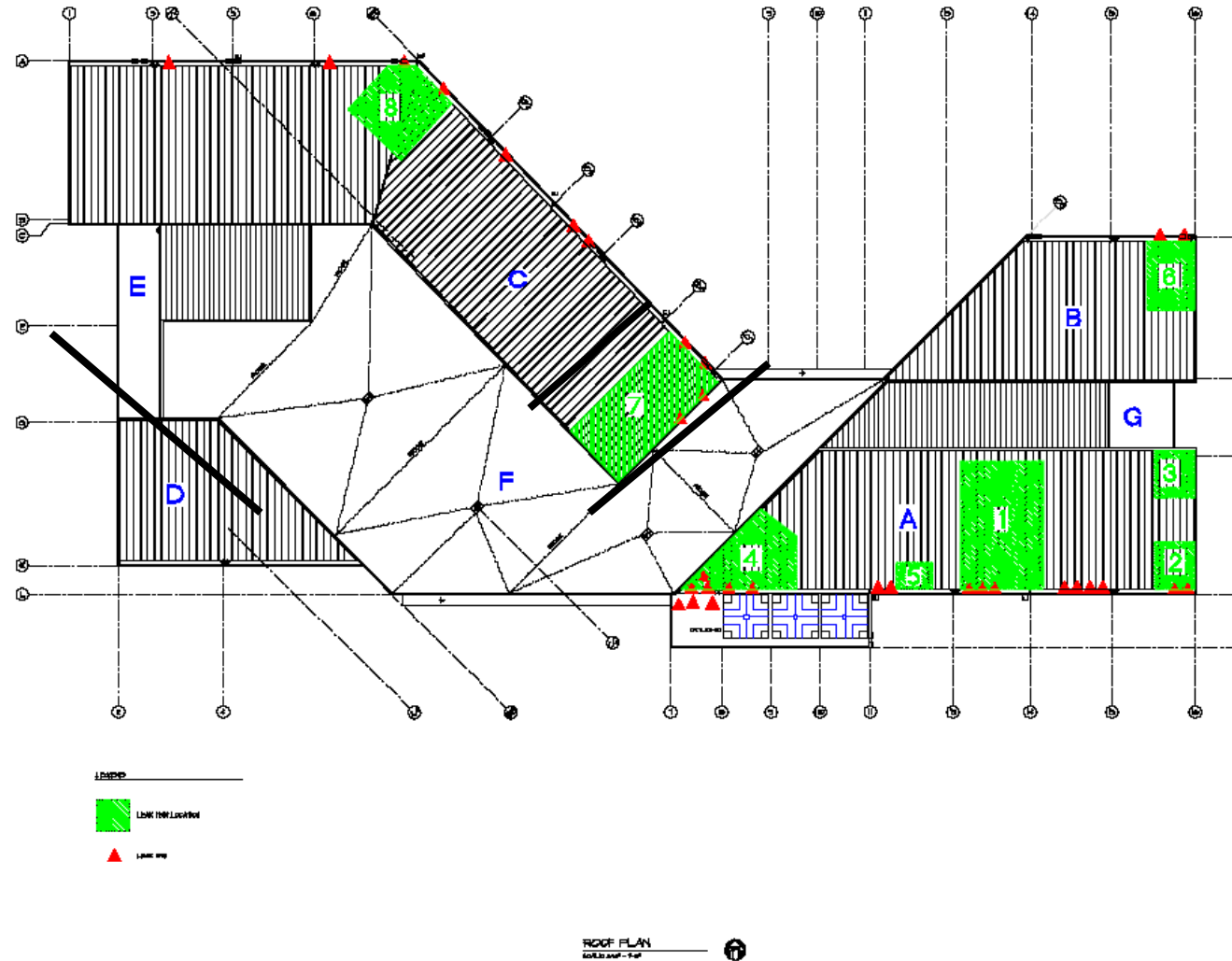
*Evidence of  
efflorescence through  
CMU wall with brick  
veneer.*







# Case Overview: *Public Library*







*Metal to single ply transitions were thought to be leak sources.*

*In earlier unsuccessful repairs, metal battens were also thought to be leak source. Note tape on batten and seam on field formed panel.*





# Forensic Methodology

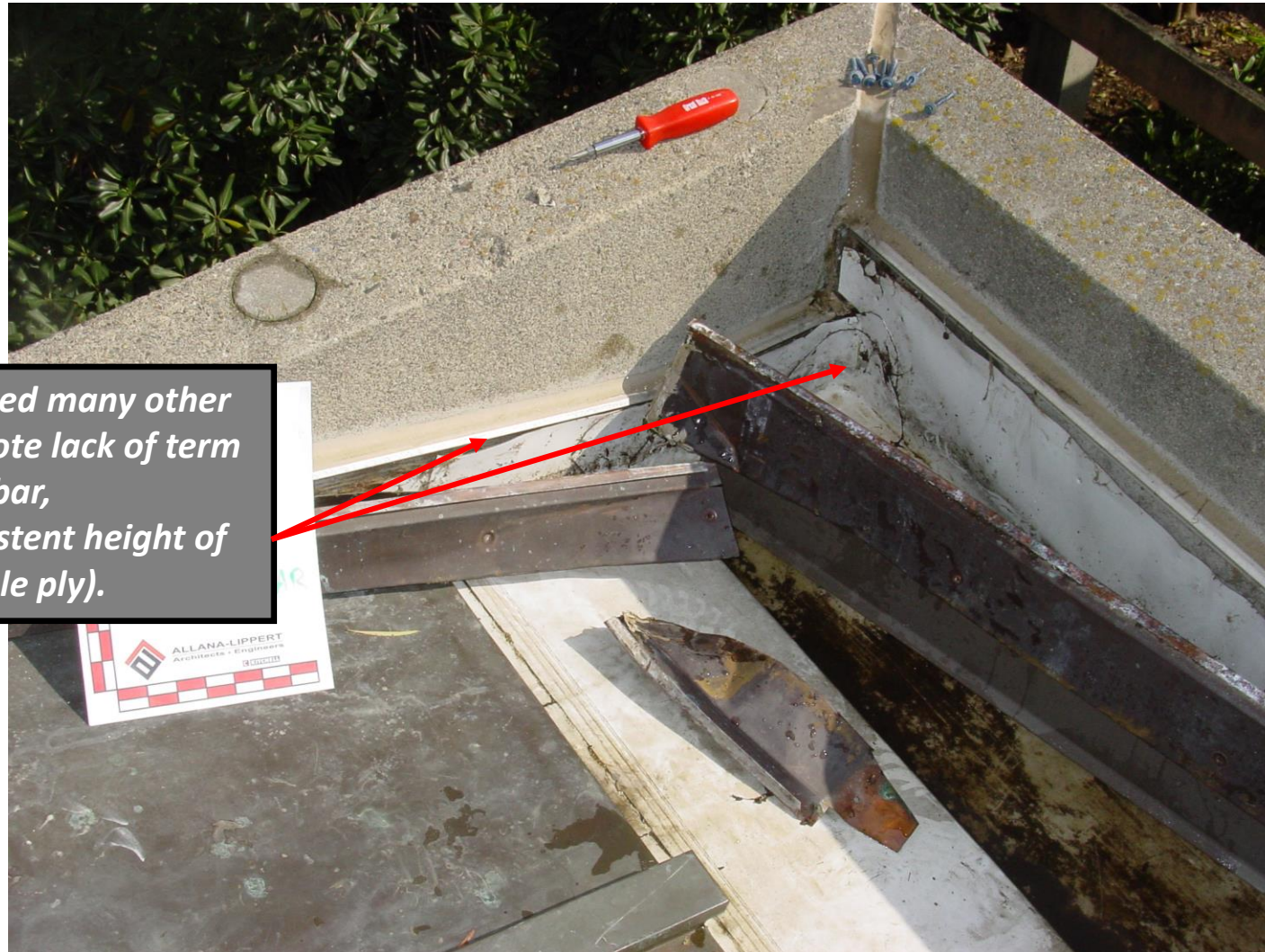
- Review plans and specifications.
- Visual inspection.
- Engineering analysis of materials.
- Code compliance investigation.
- Water testing.
- Destructive testing.
- Preparation of a defect report and budget.

# Testing at Gutter

- Destructive testing.
- Water testing.
- Visual assessment.
- Measurements.



*We uncovered many other problems (note lack of term bar, and inconsistent height of single ply).*



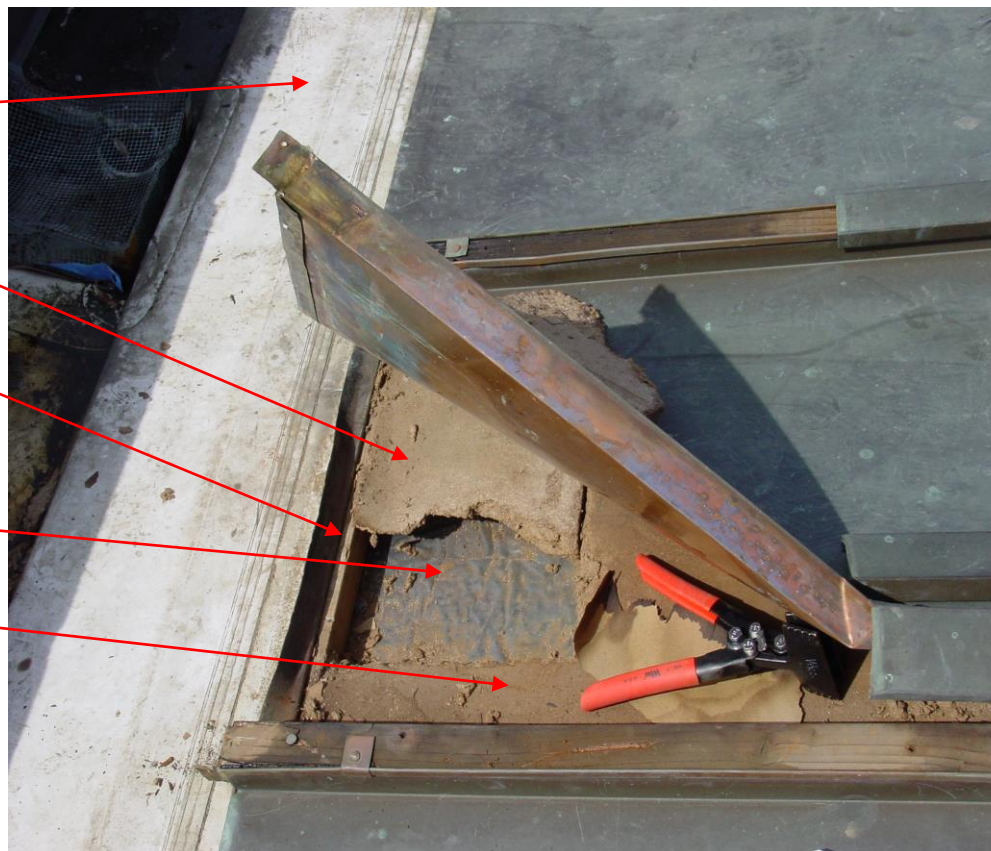
PVC gutter Liner

Original copper gutter liner

2x4 used to support copper gutter

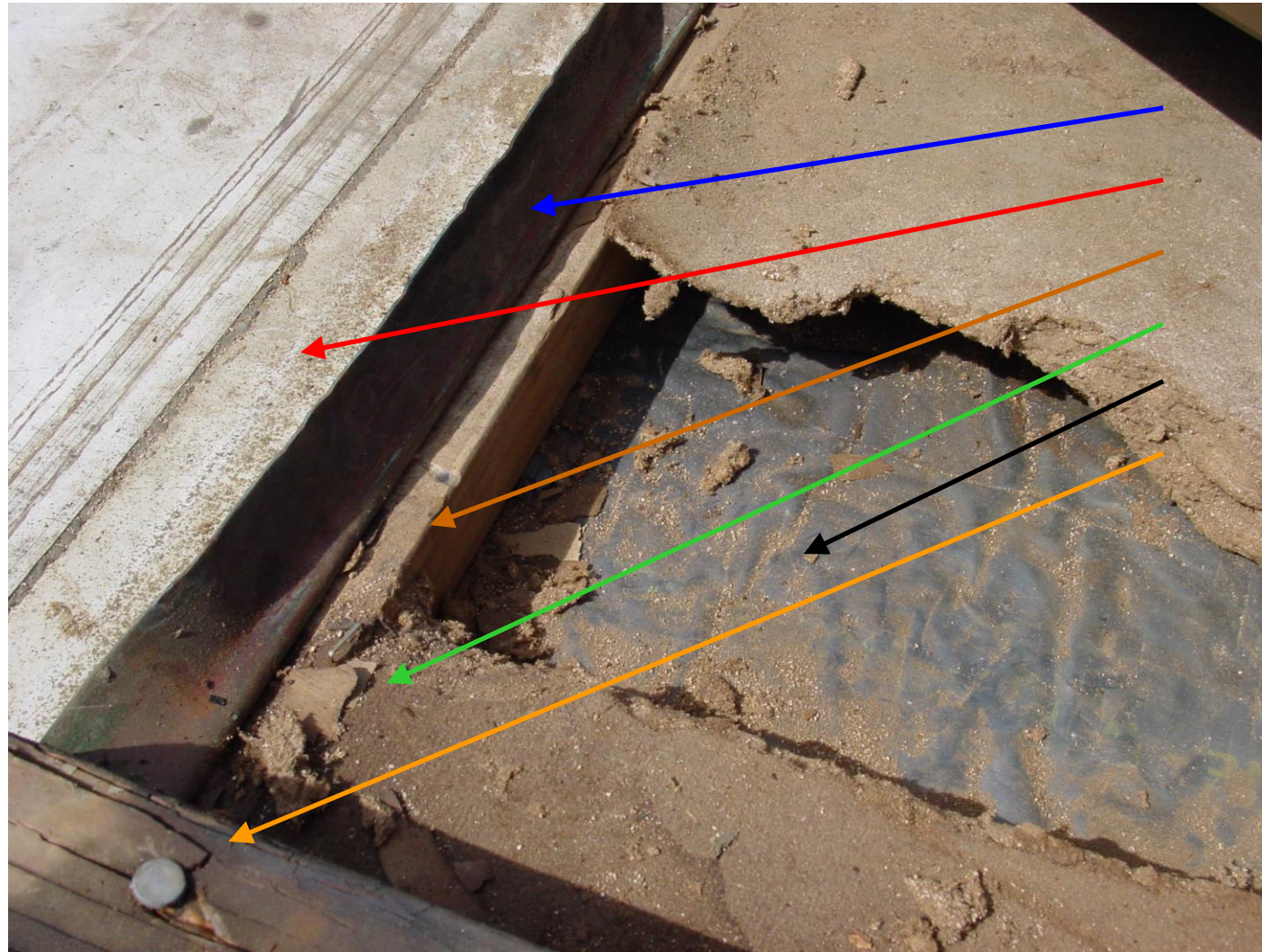
Underlayment

1.5-Inch perlite insulation





# Conditions Found During Destructive Probing



Original Copper Gutter Liner

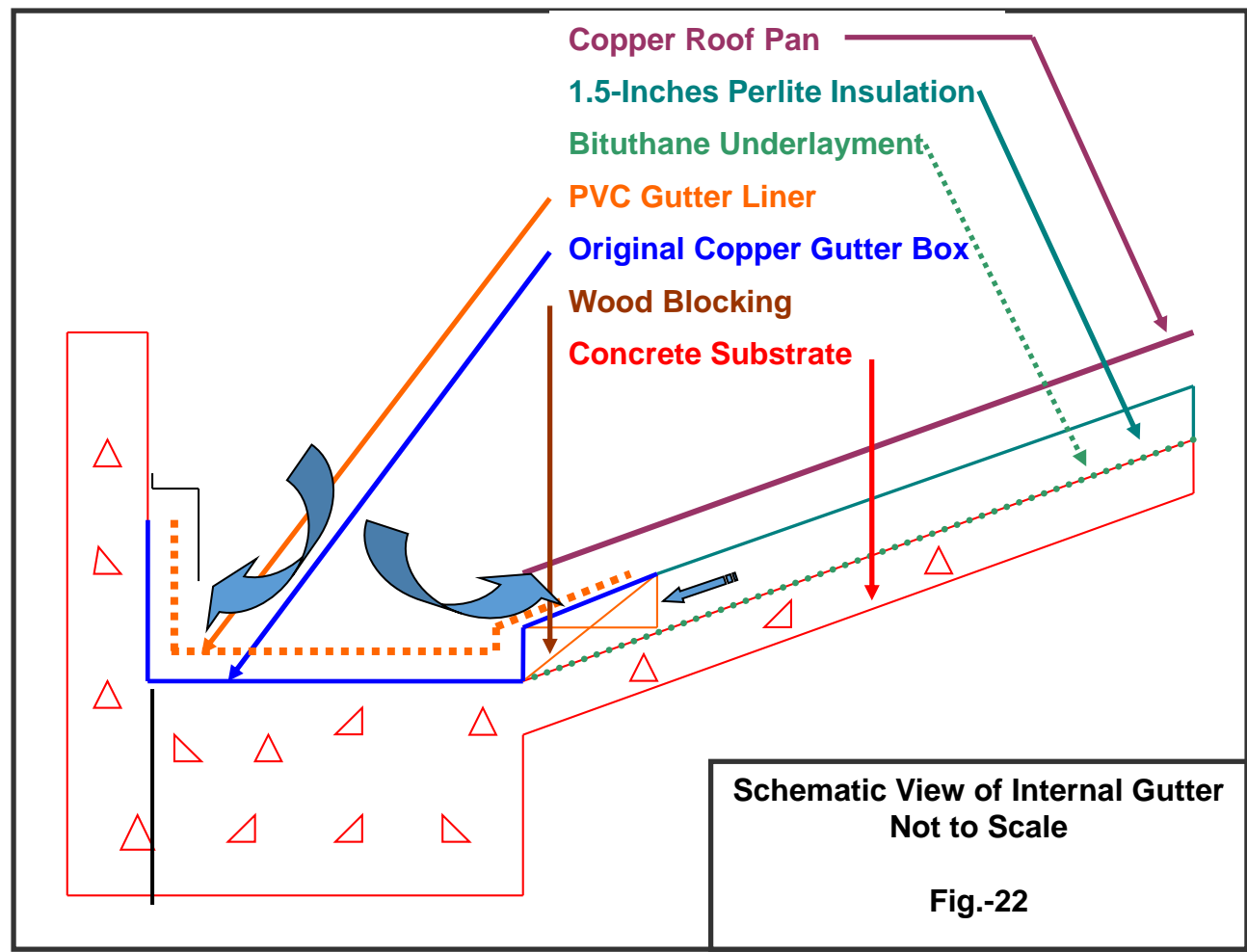
PVC Gutter Liner Added Later

Wood Blocking


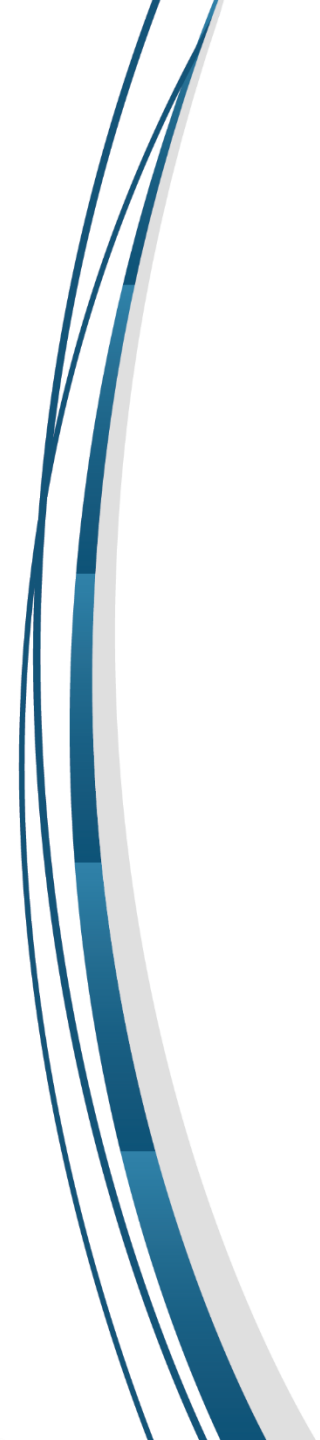
1.5-Inches Perlite

Bituthane Membrane

Wood Batten







*Water in gutter was found to be running under counter flashing when gutter is full. Additional water is presented from copper roof pans.*

# Testing at Confined Rake

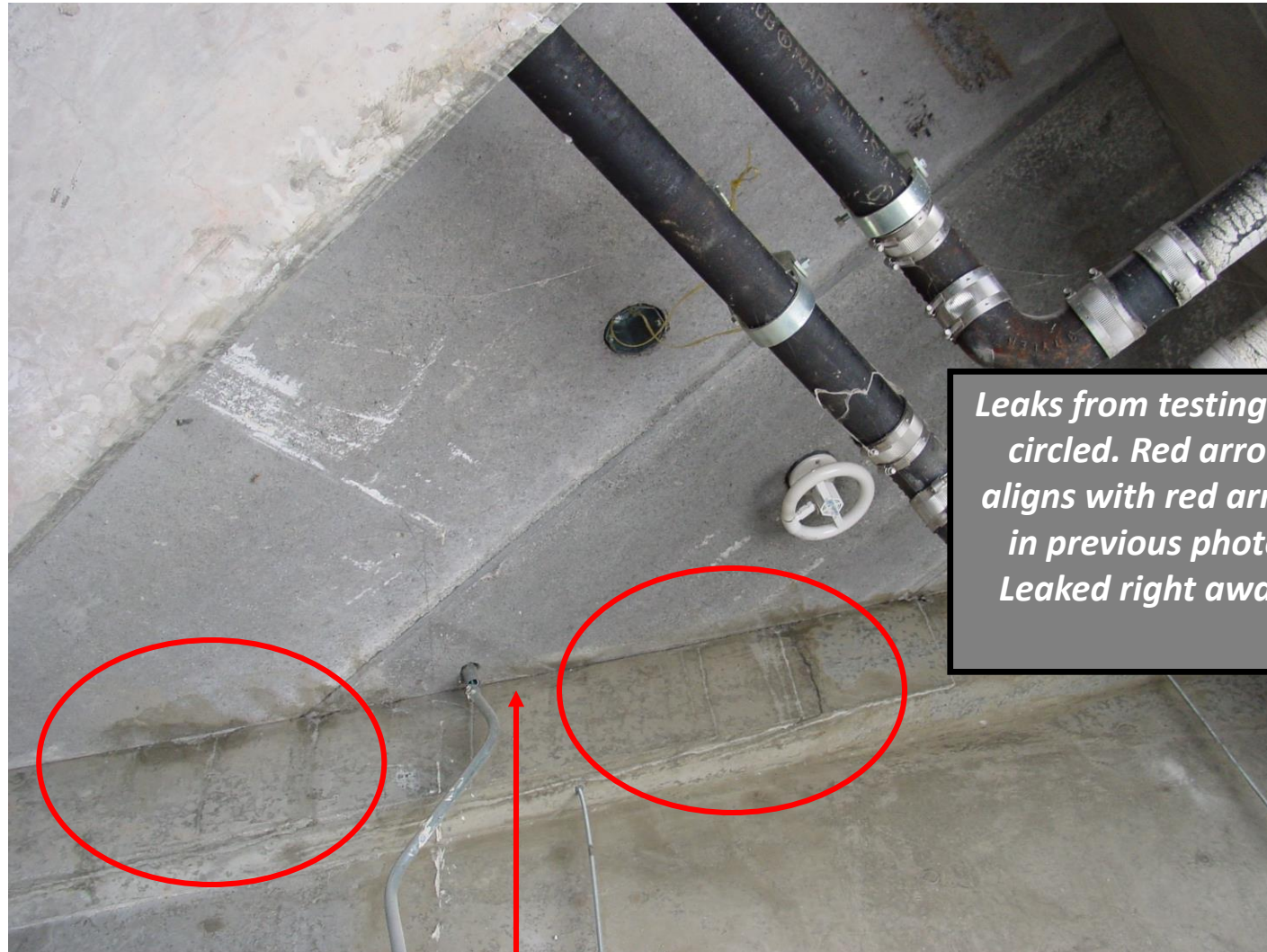
- Destructive testing.
- Water testing.
- Visual assessment.
- Measurements.



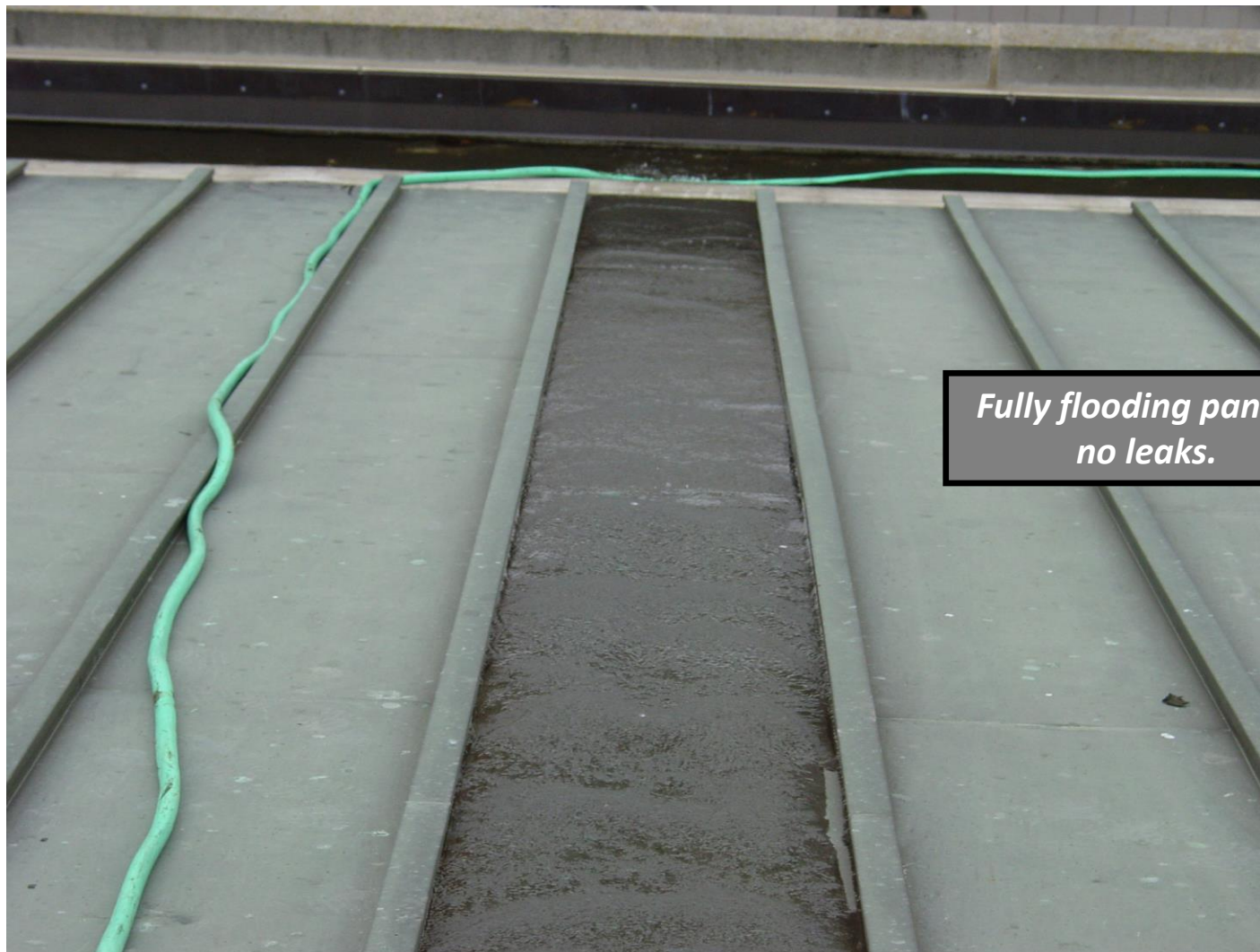






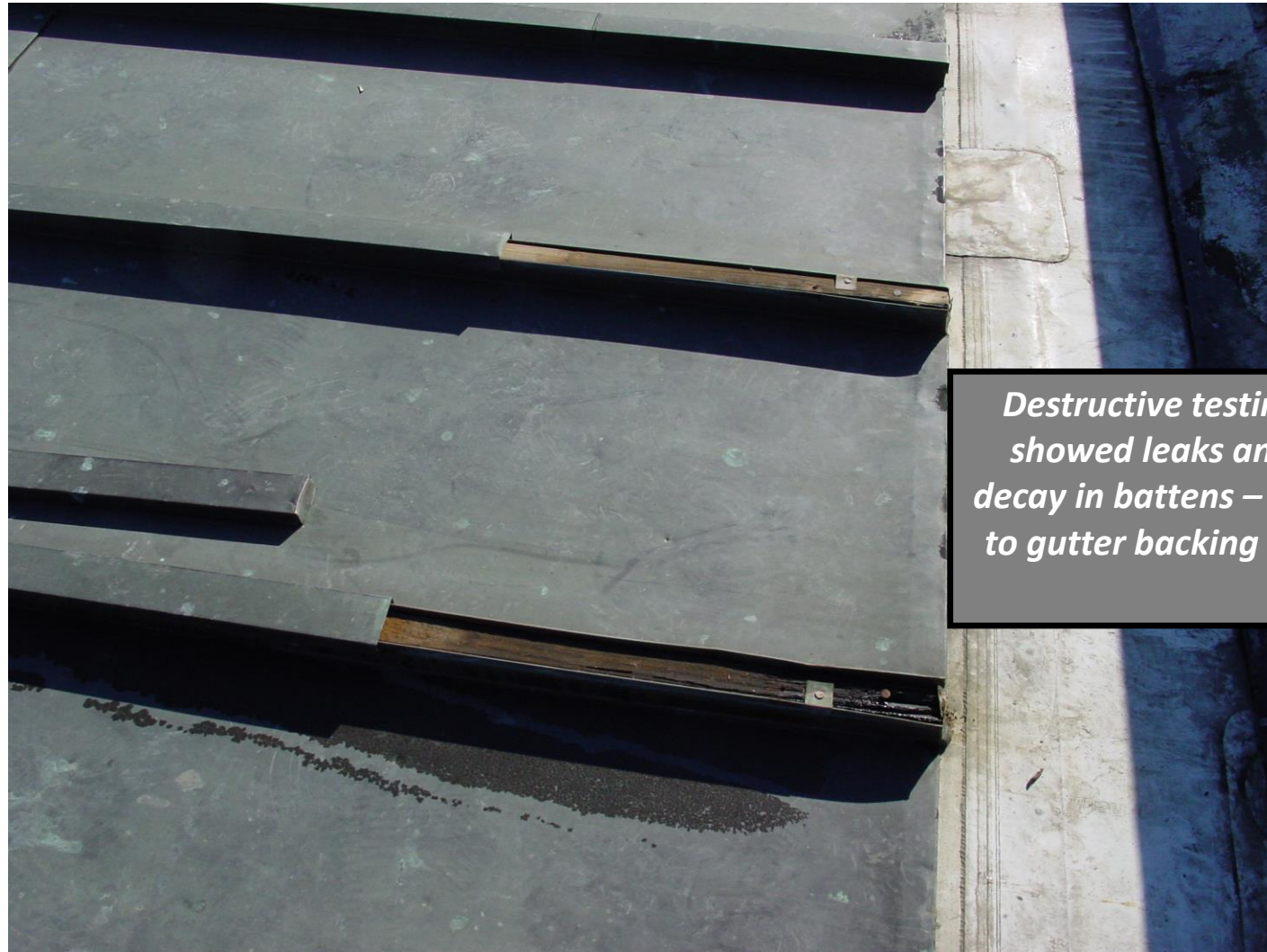


*Leaks from testing are circled. Red arrow aligns with red arrow in previous photo. Leaked right away!*



*Fully flooding panel –  
no leaks.*





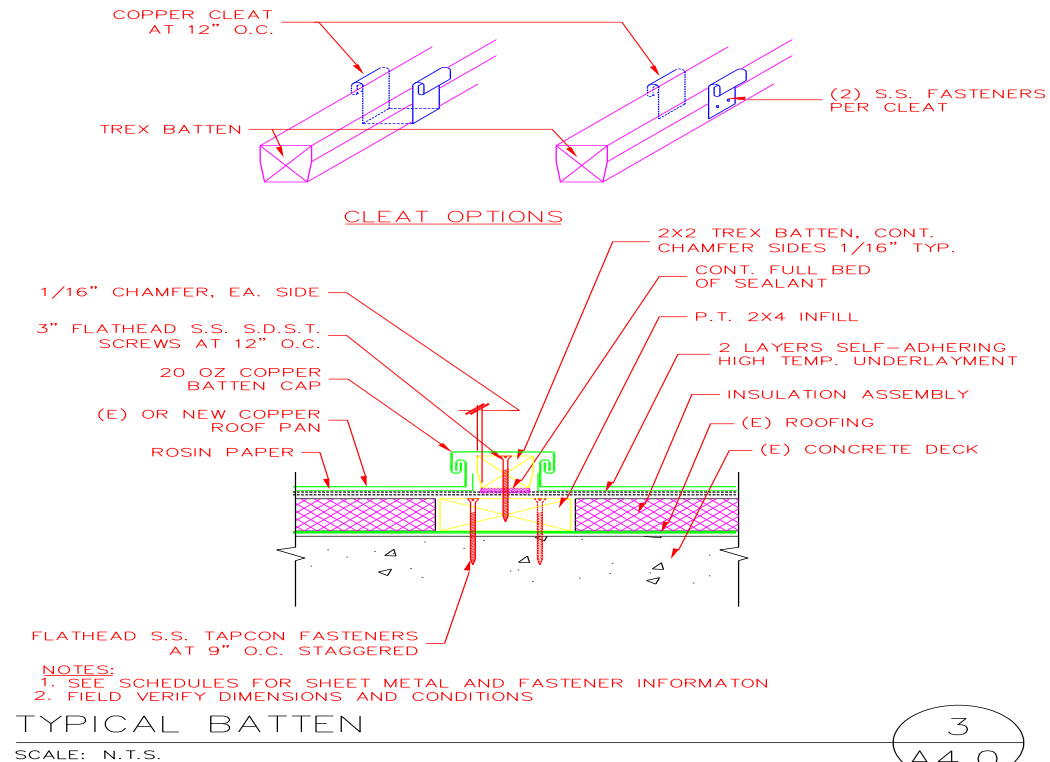
*Destructive testing  
showed leaks and  
decay in battens – due  
to gutter backing up.*



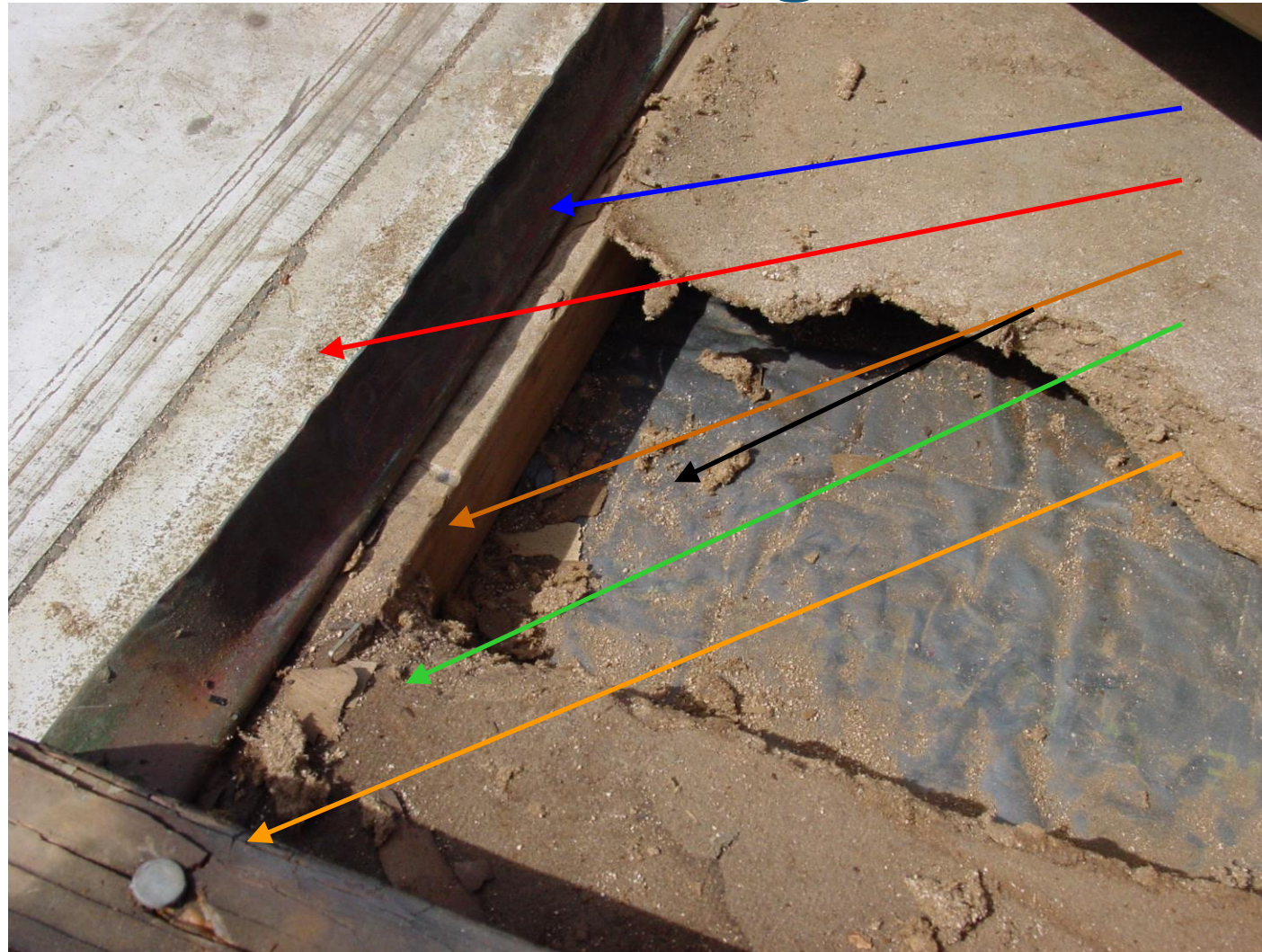
*Batten end not properly constructed – did not allow water to weep out.*



# Batten Repair



# Conditions Found During Destructive Probing



Original Copper Gutter Liner

PVC Gutter Liner Added Later

Wood Blocking

1.5-Inches Perlite

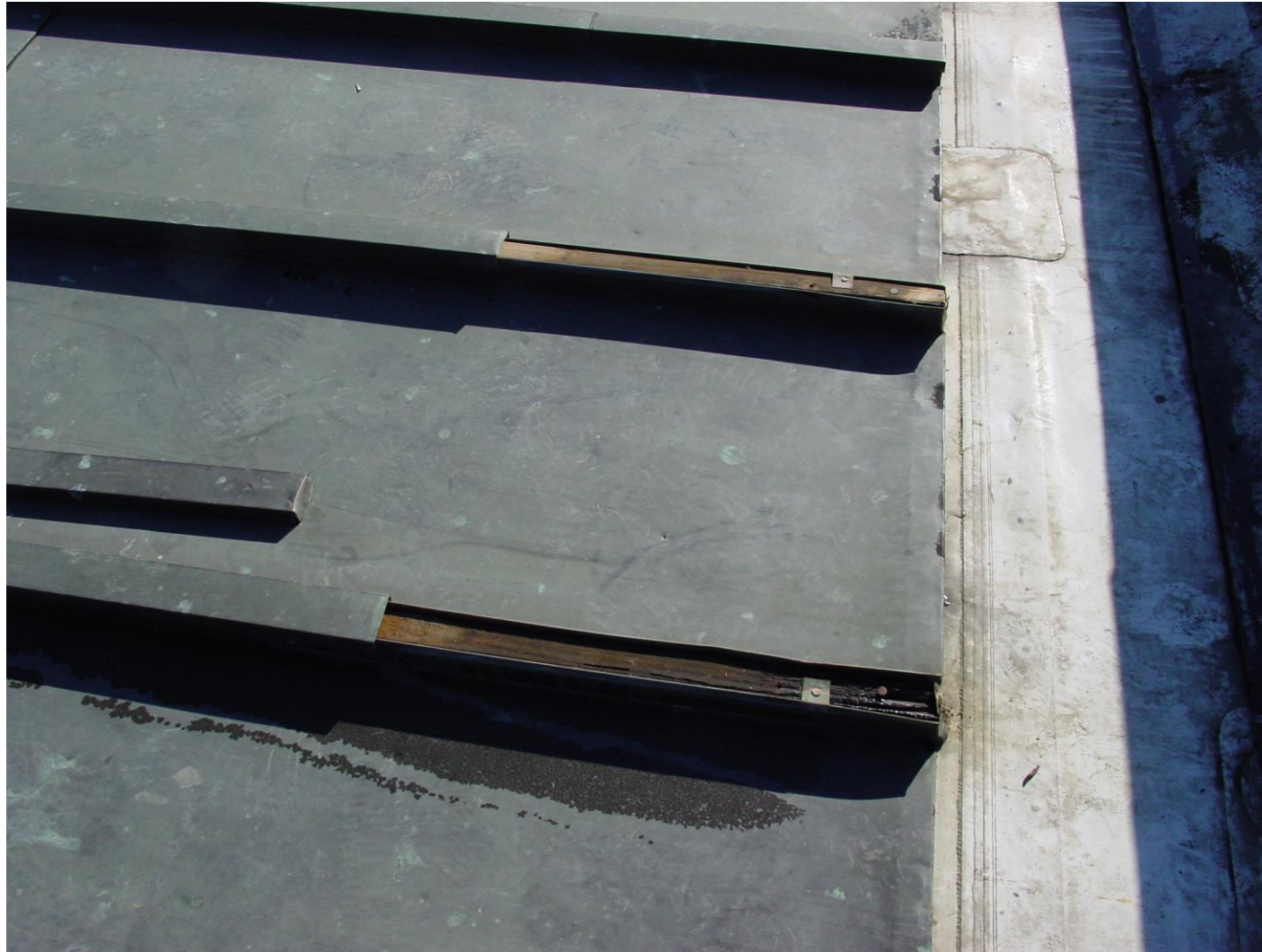
Bituthane Membrane

Wood Batten





# Recommended Repair: *Copper Roof*



- Remove and store copper roof.
- Demolish flashings.
- Demolish Perlite insulation.
- Install treated wood stringers.
- Install Isocyanurate insulation.
- Apply two layers of underlayment.
- Reinstall copper (90% re-use).
- Install new copper flashings.
- Perform concurrent gutter repairs.
- 50 year life expectancy.



# Recommended Repair: *Internal Gutter*



- Demo PVC and copper liner.
- Demo flashings.
- Cut large 8x12-inch scuppers.
- Cap existing outlet drains.
- Install concrete sloping fill.
- Install PVC gutter liner.
- Install flashings.
- Provide copper collector heads.
- Install copper downspouts.
- Provide connection to field drains.
- 50 year life expectancy.



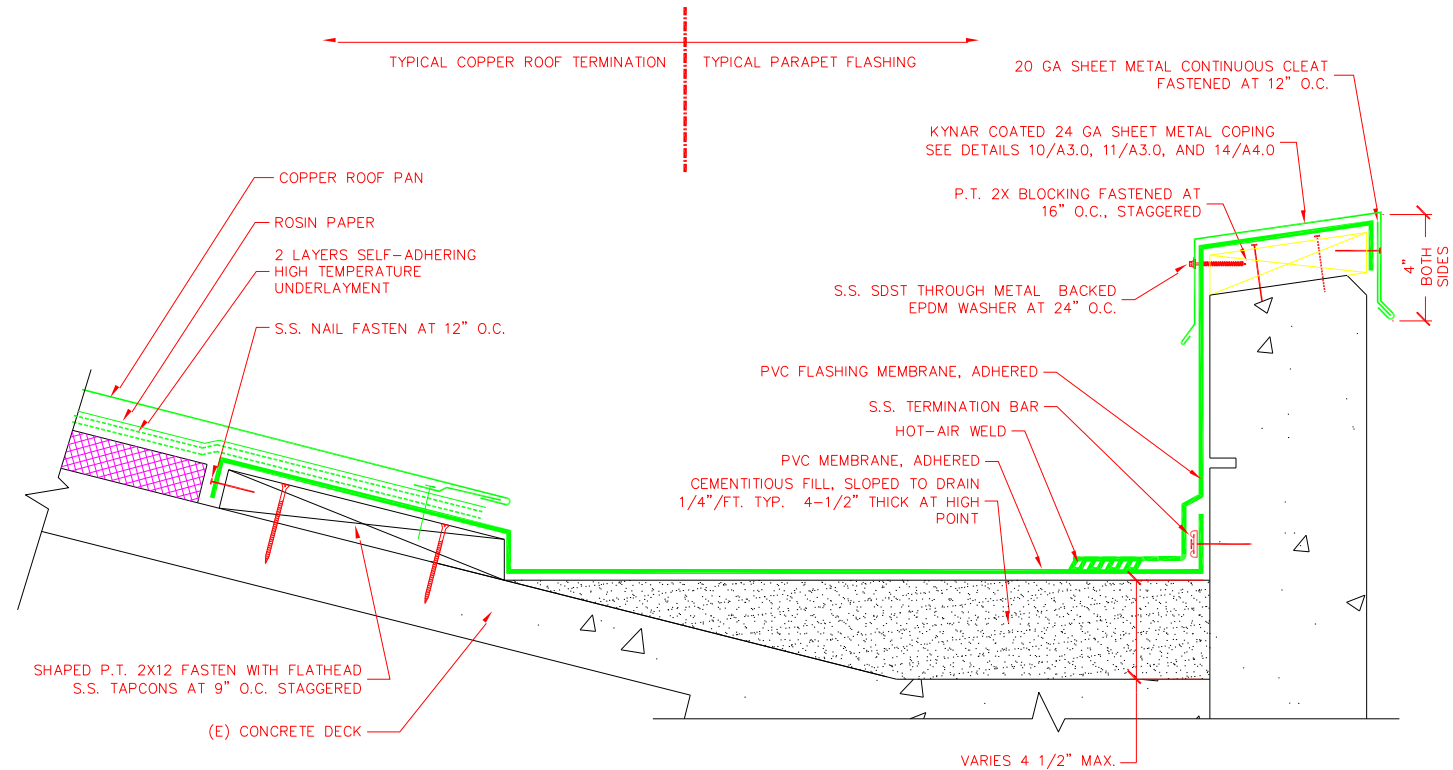
# Recommended Repair: *Brick Veneer Walls*



- Demo brick veneer.
- Install waterproof membrane
- Install copper through-wall flashing.
- Install cavity drainage panel.
- Reinstall brick veneer.
- Use plastic weep channels.
- Provide perimeter sealant joint.



# New Gutter Detail

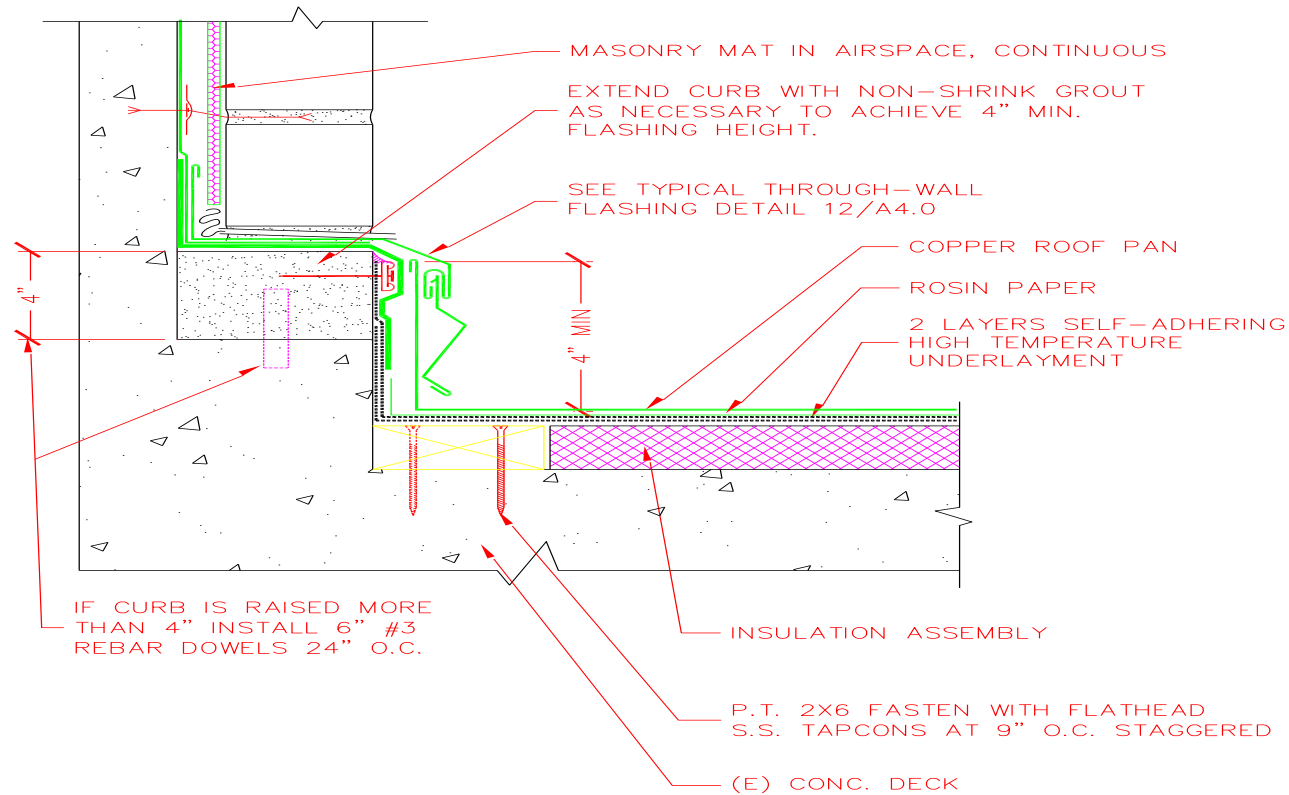


TYPICAL GUTTER SECTION

SCALE: N.T.S.

1  
A3.0

# Brick Wall/Rake Repair



## NOTES:

1. SEE SCHEDULES FOR SHEET METAL AND FASTENER INFORMATION
2. FIELD VERIFY DIMENSIONS AND CONDITIONS

COPPER ROOF RAKE AT BRICK

SCALE: N.T.S.

1  
A4.0



# Repair Costs: Recommended Repairs

Description	Cost	Life Expectancy
Restore Copper Roof	\$ 488,000	50 Years
Rebuild Internal Gutters	\$ 47,000	50 Years
Rebuild Rising Walls	\$ 48,000	100 Years
<b>Total Estimated Repair Cost (+/- 15%)</b>	<b>\$ 583,000</b>	

# Lessons Learned

- Previous studies were visual only, did not identify all the problems.
- Previous repairs were unsuccessful.
- Isolating the building components was necessary to identify source of leakage.
- The original design was also suspect (gutter design, improper placement of roof underlayment, improper design and construction of brick cavity wall).





# Metal Roofing Architectural Roof Systems



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# Metal Roofing



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# Roof Defects: *Whose Responsibility?*



*Improper design leads to failures.*

# Lessons Learned

- Again, failure to follow manufacturer recommendations.
- Basic design was lacking – flashing and other problems.
- Application was not closely monitored – a consistent problem with tile.



# Life Expectancies...

- Sealants: 10 to 25 years
- Roofs: 20 to 30 years
- Below grade waterproofing: Life of the building
- Windows: Life of the building
- Window gaskets: 15 to 20 years
- Stucco: Life of the building
- Painting: 5 to 7 years
- Hardboard siding: 25 years

# Owner Responsibility For Ongoing Maintenance

- Frequently Occurring Items Like:
  - Gutter cleaning
  - Debris cleaning
  - Annual inspection of roofs, sealants, windows, walls and exterior façade
  - Tree trimming
  - Low pressure power washing exteriors of building



# Owner Responsibility For One Time Repairs

- Damage from trees and roots.
- Damage from cars and foot traffic.
- Damage from vandalism or abuse.
- Severe storm, earthquake, hail, hurricane, and other natural phenomena.
- Damage from oil and chemicals.

# Contractor Responsibility for Defective Construction

- If a 20 year type roofing system needs “repairs” other than items on two previous slides, within the first ten years.
- If 10 year sealant types need replacement or fail in less than their life expectancy.
- If windows leak in fewer than 10 years.
- If other materials that do not last their normally expected lives, and fail within the first ten years.



# Evaluation

- Study historic leak and repair patterns.
- Record when seen.
- Visual observation by a trained eye.
- Leak testing, non-destructive moisture testing.
- Destructive testing