Building Envelope Preventive Maintenance and Repair
Roofs, Solar, Curtain Walls, Exterior Cladding; and Budgeting Tips

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EDUCATION: B.S., Civil Engineering, Santa Clara University

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CERTIFICATION: Registered Roof Consultant (RRC), and Registered Waterproofing Consultant (RWC), from the Roof Consultants Institute (RCI)

OVERVIEW:

– Experienced Instructor and Presenter – UC Berkeley Extension Certificate Program in Facilities Management, RCI, Solar Solutions, AIA’s Continuing Education System and other professional organizations – over 200 programs and sessions.
– Over 23 years experience providing superior technical standards in all aspects of building technology.
– 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 1000’s of projects in new construction, addition, rehabilitation, remodel and modernization projects, for public and private sector clients.
– Specialization in roofing; solar; curtain walls; building cladding including cement plaster (stucco), wood, GFRC and metal panels; water intrusion preventive maintenance and damage repair; window assemblies and storefronts; below grade waterproofing; and other complex building envelope and mechanical assemblies.
• ABBAE is an Architectural Engineering Firm specializing in making buildings last longer.

• We enhance the value of the building asset for owners and operators.

• Specialty components include Roofing, Solar, Waterproofing, Curtain Walls, Stucco, Windows, Below Grade, Etc.

• Our 2000+ projects: 45% have been new Construction projects, and 55% Repair and Rehabilitation projects.

• Consultants to 100’s of Facility Managers.
OBJECTIVES

✓ Provide a very general overview of proper design of the building envelope, so you can recognize problems.
✓ Help you understand what to look for, so that PM can be prioritized and done when needed.
✓ By providing some Preventive Maintenance examples, provide you knowledge to build on.
✓ Help you understand the operating issues associated with building envelope maintenance.
✓ Provide a basic understanding of what to look for
✓ Provide information to get you started in budgeting for Preventive Maintenance
✓ And how to watch out for hidden dangers…
Hidden Dangers Can Be Expensive
**Best Preventive Maintenance**

- **Best preventive maintenance?**
  - One that is not needed!

- **Design a Building that requires very little maintenance**

- **Poorly built or designed details are like “TIME BOMBS”**

- **Repairing roofs that “leak” within normal warranty is often due to “Construction or Design Defects”**

- **Owner Required Items:**
  - Regular Inspection of roofs and facades
  - Debris not allowed to accumulate on roof
  - Regular cleaning program – remove blowing trash, leaves, branches
How to Achieve 30+ Yr Low Maintenance Roofs?

- Good Design and Proper Installation!
- Good UV protection. Gravel surfacing, UV and heat resistive materials, Reflective Coatings
- Proper details such as drains, sleepers, base flashings, all designed to last 30+ years, not just the membrane
- Prevent contamination from chemicals
- Design for appropriate foot traffic
- Design for appropriate UV and heat exposure
- Design for ease of adding HVAC units or pipe penetrations if needed
Hot Applied Built Up Roof (BUR)

Appropriate delivery of hot asphalt and appropriate roofing over mechanical curbs.
DEFECT: Lack of brooming of felts and improper temperature caused voids and poor saturation of roof felts.
DEFECT: Improper application of primer (on new roofs and upon adding equipment to an existing roof) coupled with lack of sufficient nailing, is the leading cause of leaks at sheet metal flashings.
Roofs go through many additions, alterations and tenant improvements, usually resulting in premature leaks and loss of life expectancy.
Example of Poor Metal Roof Penetrations

New vent pipe was improperly added by tenant.

Proper installation.

Pipe Diameter

1/2 in. min.

Cutting Guides

Unit Height

Base Diameter
This Parapet Wall Could Use a Cap.

Parapet Wall Designed to Last 5 to 6 Years, Heavily dependent on maintenance to keep it water tight for 20+ years

The roofing cement is pulling away from the concrete wall, providing a route for water to infiltrate behind the roof assembly. Repair or sheet metal cap is needed, if roof is not being replaced soon.
Low Maintenance Parapet Wall Design

22 GA G5M CONTINUOUS CLEAT FASTENED AT 12" O.C.
KYNAR COATED COPING
SELF-ADHERED FLASHING
TAPERED PERLITE, CONTINUOUS.
(E) 2X6 TOP PLATE

FASTEN BASE FLASHING AT 6" O.C.
FASTEN AT 24" O.C. THROUGH NEOPRENE BACKED METAL WASHER
(E) PLYWOOD ON WOOD PARAPET FRAMING

CANT STRIP
BASE FLASHING
BUILT-UP ROOFING
INSULATION ASSEMBLY
PLYWOOD ROOF DECK

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Poor Sleeper Construction

*The Sleeper detail will require maintenance every 1 to 2 years to keep it watertight.*
More Sustainable Sleeper Detail

BOLT EQUIPMENT OR EQUIPMENT SUPPORT TO SLEEPER THROUGH 1/8" THICK NEOPRENE PAD, TYP.

24 GA. G.S.M. CAP, SOLDERED TO FORM ONE PIECE

ICE & WATER SHIELD

4 X 6 M.N. PRESSURE-TREATED DOUGLAS FIR (P.T.D.F.) SLEEPER

1/2" DIA. COUNTER SUNK LAG BOLT OF SUFFICIENT LENGTH TO PENETRATE CENTER OF (E) FUR LIN/GLULAM 4" M.N. AT 4'-0" O.C., TYPICAL. SEE PLAN x/x.

WOOD BLOCKING TO MATCH INSULATION HEIGHT

(E) PLYWOOD DECK

WOOD CANT 4 SIDES

TWO PLIES FLASHING SHEET
FLASHING SURFACING SHEET
INSULATION ASSEMBLY

CAP SHEET
BUILT-UP ROOFING
Base Flashing Repairs OR Maintenance?

Base flashings (Horizontal to vertical junction) are exposed to more UV and physical abuse.
If the roof can not be repaired at least eliminate ponding and poor condensate drainage!
Proper Material Selection

Foam Roofing on an industrial building = bad idea.
Proper Maintenance Cycle

Foam roofs require acrylic recoating every five years!
Maintenance or Repair?
Single Ply PVC Roofing
Excessive Wear and Abuse

Construction debris accumulated on roof – bad idea
Membrane damage, most likely from due to a dropped tool or sheet metal.
Pipe and pipe supports have moved, compromising life of roof.
Improper Tenant Improvement Work

Electrical conduit added and pipe jack added, both set in mastic that is incompatible with PVC.
Gutter Defect Requires More Maintenance

Slope in gutter was omitted, resulted in weed growth, which restricted flow of water and caused leaks and increased need for maintenance.
Preventative Maintenance
Roof Coatings

Extending the
life of roofs and meeting
Energy Star Compliance
with
White Acrylic Coatings
Properly installed cap-sheet roofs have a life expectancy of 15 – 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.
Solar PV Installations On Existing Roofs
How Solar PV Works
Improper Mounting and Racking

Roof Mount - Attached to Structure

What is wrong with these pictures

Attached to Structure

Angled Attached to Structure
PV Installations on Existing Metal Roofs

• Our philosophy of design:
  • Sustainable means removing uncertainty about performance and longevity

• We consider all factors:
  • Structural
  • Roof Condition and Assessment
  • Site Condition and Entitlement Process

• We design systems that will stand the test of time

• Design flashings that don’t void roof warranty
Proper Mounting and Racking

Roof Mount - Attached to Structure
Can The Existing Roof Handle Solar?

• **Constructability**
  
  • Structural Engineering Considerations
    • Load, Seismic, Wind
  
  • Roofing considerations
    • Age and condition
    • Integration
    • Warranty
    • Waterproofing
    • Drainage
    • Maintenance access
    • Installation damage controls
    • Chemical compatibility
Site Assessment and Site Control

• Physical Constraints

• Available area on your roof?
• How much mechanical equipment is on roof?
• Access clearances required for maintenance of mechanical equipment?
• Does local fire code affect clearances?
• Conduit runs possible from solar to electrical tie in?
• Space on ground for a mounting system?
• Over a parking lot or parking structure?
• Trench from this area to electrical tie-in point possible?
• Space for inverter? Outside? Inside?
• Inverter(s) require closed in structure?
• Type of structure? Space required?
• Security issues?
Solar Roof or Garden Roof?
Is This a Good System For Your Roof?
Importance of Maintenance

Excessive dirt build-up on PV modules creates “Hot Spots”. Can cause cell series wiring to prematurely fail and VOID the manufacturer’s warranties.
Thermal movement can damage the roof
Importance of Solar Maintenance

- Warranties - which may not be honored if no proof of proper maintenance is documented
- Inverters, Panels, Combiner Boxes can fail prematurely due to excessive heat build-up
- Photovoltaic systems are designed to last 30-40 years
  - Chaffing wires or faulty mounting hardware can be detected early with a regular maintenance program.
- Simple problems may reduce the life expectancy of the PV system
- Without proper inspection and cleaning, production guarantees may be violated
- According to the National Renewable Energy Laboratory, soiled modules can show a deficiency of 25%
Curtain Wall Maintenance.
The 3 Basic Glazing Systems

• Curtainwall - Prefab units attached to the edge of slab, then weather-sealed in place or factory sealed to a certain extent.

• Storefront-Typically floor to ceiling, includes entrance doors and vestibules. Field installed from floor, frames first then glass placed in the frame, then stop is snapped in place.

• Windows-Individual units fixed or operable, set in a wall.
Store Front Systems

• Glass is supported by blocks
• Gaskets act as spacers and hold glass in frame
• Designed to leak due to gaskets not always tight to glass
• Designed to move ¼” per 20 feet
• Requires review and maintenance
Curtain Wall

- Building Façade which does not carry any dead load from the building other than its own dead load
- Loads from curtain wall are transferred to building at edge of floor slab
- Designed to resist air and water infiltration
- Resist wind and seismic pressure acting upon it.
- Curtain walls frame commonly in-filled with glass, but can be in-filled with stone veneer, metal panels, vents
Metal Studs Curtain Wall

Solutions:

- Include the installation of the metal studs in the architectural wall installers scope of work

- Studs outboard of the floor slab, with slip connectors, eliminate the deflection problem
Curtain Wall Materials

- Glass
- Metal
- GFRC
- Pre-cast concrete
- EIFS (not common)
- Masonry (also not common)
System Vulnerabilities

Leak observed on the 2nd floor after the first spray test at the GFRC panel

Leak observed on the 1st floor after the third spray test at the (inviso vert.)
Leak observed on the 1st floor after the third spray test at the...
Curtainwall

A curtainwall is mechanically anchored to a building’s primary structural frame and is constructed of various component types.

It carries only its own dead and live weights, not that of the building.
Mounting Brackets
Sealants and Gaskets on Curtain Walls and Store Fronts
Types of Sealants and Application

Types of Sealants

1. Low, Medium and High Modulus Silicones
2. Perimeter sealants need to be Low Modulus
3. Structural sealants need to be High Modulus
4. Internal sealants need to be Low Modulus or Non Hardening

Sealant Application

1. Proper Cleaning
2. Priming if necessary, testing required
3. Proper tooling and cure times
4. Constant quality control throughout installation

Backer Rod Types

1. Closed Cell
2. Open Cell
Sealant Joint Movement Over Time and Temperature

Source: Dow Technical Manual
Typical Backer Rod and Sealant Joint

**Typical Backer Rod and Sealant Joint**

**SEALANT THICKNESS** = \( \frac{1}{2} \times \text{JOINT WIDTH} \)

\( \frac{3}{4}'' \text{ MIN} \)

**SURFACES CLEANED AND PRIMED, TYP.**

**SEALANT, FACE TOOLED CONCAVE, U.O.N.**

**COMPRESSED BACKER ROD, ORIGINAL DIAMETER** = \( \frac{1}{2} \times \text{JOINT WIDTH}, \text{ AND/OR BOND BREAKER TAPE AS SHOWN OR NOTED} \)

**BONDING SURFACE**

\( \frac{3}{8}'' \text{ MIN TYP} \)

\( \frac{1}{4}'' \text{ MIN TYP} \)
Depth to Width Ratio 2:1

1. Dimension A must be at least 1/4" (6 mm).
2. Dimension B must be at least 1/8" (3 mm).
3. Dimension C must be at least 1/4" (6 mm).
4. Ratio of A:B should be 2:1 minimum.
5. Joint surface tooled.
6. Dimension B suggested Maximum = 1/2" (12.7 mm).
7. Dimension A Maximum = 4" (100 mm). Joints wider than 2" (50 mm) may slump slightly; therefore double application of the sealant may be required.

Source: Dow Technical Manual
Metal Surface Preparation for Maintenance

- **Anodized aluminum** - typically EXCELLENT for sealant adhesion.
  - Anodized finish often varies between anodizer manufacturer
  - Anodized finishes typically do not require a primer
  - **Clear** Anodized can sometimes be difficult - may require primer
  - Surface prep is most always IPA wipe

- **Painted aluminum** - widely variable, dozens of paint manufacturers.
  - Painted finishes - good chance primer not required
  - Surface prep is almost always IPA wipe

- **Lead, Copper, Stainless & Galvanized** - use Neutral cure sealants.

- **Unpainted steel** will corrode causing adhesive release of sealant.
Why Use Silicone?

✓ Unmatched UV Resistance
✓ High Strength
✓ Outstanding Flexibility
✓ Wide Thermal Performance Range (Thermal Stability)
✓ Wide Application range
✓ Excellent Adhesion
✓ Custom-Tailored Formulations
Organic sealants stiffen and lose flexibility at colder temperatures, placing stress on the bondline(s)
Sealant Pull Test
Sealant Adhesion Testing
Project Example
Kaiser Sealant Repair
Kaiser - Sealants on Precast and Curtain Wall
Sealant Between Curtain Wall and Pre-Cast
Sealant Between Pre-cast and Mullion
Gasket Shrinkage/Failure
Budget Tips for Typical PM Tasks – Sealants

✓ Wet seal window gaskets, including the following steps
  – Properly prepare the area
  – Clean and wash windows
  – Remove metal caps
  – Remove loose gaskets
  – Cut remaining gaskets
  – Apply wet seal and replace caps
  – $4.50 - $7.50 per lineal foot

✓ Replace sealants between GFRC and other panel types, including the following steps:
  – Remove existing sealants and backer rods
  – Perform adhesion test and if necessary, grind the bonding area
  – Replace backer rod and sealants, properly tooling the sealants
  – $5 to $10 per lineal foot, depending on prep time
Leak Testing Curtain Wall
EIFS Wall Systems May Have Drainage + Weep

 Unless system is tested as a “Barrier System” it must have weather resistive barrier and weep mechanism.
EIFS Preventive Maintenance - Investigation

EIFS exterior on building at large Silicon Valley Campus. Occupant of office had reported major leaks.

ABB was hired to determine causes and if possible prescribe major preventive maintenance repairs rather than very expensive replacement of entire skin of all 13 buildings (several $$$$ million).
Client Had Made Attempts at Repairs

Campus owner had attempted repairs, without much success. Repair sealants had failed to adhere and we determined that there were other problems.
Cracks Smaller Than Hairline, in Field of EIFS
Removal of ceiling tile showed more evidence.

We saw some limited evidence of leaks – most of the evidence had been painted over but when we removed ceiling tile....
Water Testing of Other Building Envelope Components
Water Testing Results
Water Testing Showed The Extent of The Problem
Result of Investigation

- Significant number of cracks were found in the EIFS, creating leaks. (Defective Construction)
- The original construction created recessed gaps between the window frame and the EIFS. These leaked.
- The windows leaked.
- The base of the walls leaked.
- The owner was faced with complete replacement of the EIFS on 12 buildings, or major preventive maintenance.
- They chose elastomeric paint, filling the recessed gaps around the windows with sealant, and sealing leaks in the windows.
Preventive Maintenance of Stucco and EIFS

• Hairline cracks can be repaired with elastomeric coating and filler, but only if the cracks are narrow (< 1/32 inch). (Cracks are due to defective construction)

• Sealants are required where the stucco transitions to other building components, such as windows. Replace every 10 to 20 years

• Remove landscaping near wall and redirect irrigation spray

• The majority of stucco/EIFS problems involve water and moisture intrusion and the failure to manage water
STUCCO
Typical Stucco System in Section

- Cement Plaster (Stucco)
- Flexible flashing
- 2 Layers Grade D paper
- Lath
- Weep provision
- Area below weep is clear (at least six inches below weeps)
High Incidence of Stucco Cracks in Metal Stud Building
Budget Tips for Typical PM Tasks - Painting

Painting

- Power wash
- Route cracks larger than ¼” and fill all cracks with proper sealant (looks ugly)
- Mask all areas
- Cover landscaping and fixtures where necessary
- One Coat Prime
- Apply finish coat, four (4) to six (6) mil thickness
- $2.50 to $4.50 per square foot not including sealant repairs

- Elastomeric Paints
  - Same steps as above plus
  - Rout and sealing of cracks is mandatory
  - Sealant around all windows and penetrations are mandatory
  - $6.00 to $12.50 per square foot not including sealant repairs
Budget Tip - Know The Normal Life Expectancies...

Sealants: 10 to 25 years
Roofs: 10 to 40 years
Gutters: 10 to 30 years
Below grade waterproofing: Life of the building if designed and installed properly
Windows: Life of the building, unless energy savings are desired, then replace as desired
Window gaskets: 10 to 20 years
Stucco: Life of the building if designed, installed and maintained properly
Painting: 5 to 7 years
Wood siding: 20 to 40 years
Sidewalks and pavement – 10 to 30 years
Landscaping – 10 to 20 years
Trees – Depends on the species
HVAC, Other Mechanical, Electrical and Plumbing – varies widely
Thank You!

Questions?