



Below Grade Waterproofing...

Introduction to Basic Types of Waterproofing and Vapor Barrier Systems, Common Failure Modes, and Design Considerations

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Allana Buick & Bers, Inc.



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Best Practice

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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

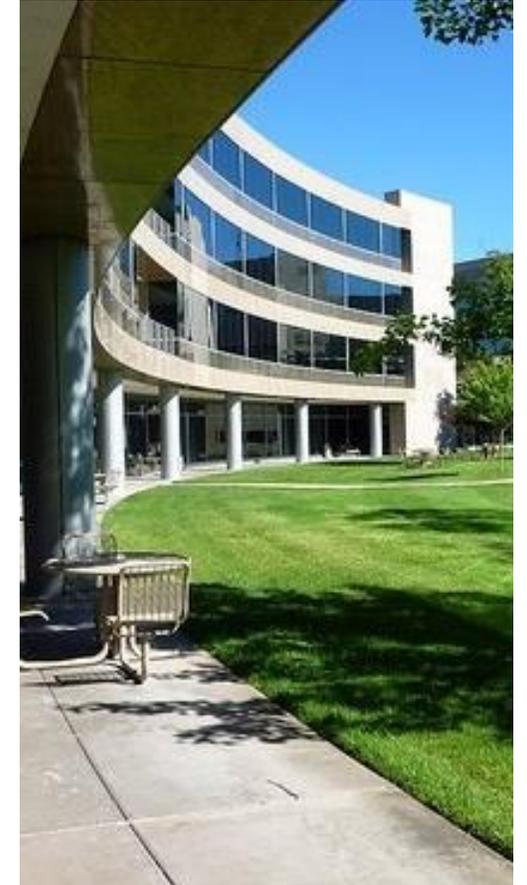
- Roofing Systems
 - High-Slope/Low-Slope Roofs
 - Green/Garden Roofs
 - Drainage Systems
 - Pedestrian Plazas
- Exterior Wall Systems
 - Wall Cladding/Siding/GFRC/pre-cast
 - EIFS/cement plaster/stucco
 - Sheet Metal Flashings
- Windows and Glazing Systems
 - Punched Windows
 - Curtain Wall/Window Wall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



Project Case Study

- Forensic Case Study Sunnyvale, California
- Waterproofing failure of Downtown Sunnyvale Garage
- Work performed for a construction defect litigation case
- Bentonite/HDPE composite system was installed and had failed
- 2nd largest below-grade structure in Northern California
- Largest below-grade waterproofing repair of it's kind in California



Project Case Study Cont.

- Structure experience extensive leaking throughout below-grade perimeter walls
- Built on zero lot line with shotcrete foundation walls against wood lagging and soldier pile retention walls



Project Case Study Cont.

- Core samples taken from 18” thick shotcrete walls
- Partial excavation behind lagging
- Reviewed original construction drawings
- Reviewed lagging installation photos
- Reviewed soil consolidation
- Visual observations of leaks and water testing

Project Case Study Cont.

- Following Picture shows the excavation of the soil behind wood lagging revealed that once the wood got wet it was
 - Swelling
 - Bending
 - Twisting
 - Especially if there were voids between the soil and wood

Downtown Sunnyvale Garage Leaked Throughout From Day 1



Chemical Grout was Injected 24" O.C.

Injection in Progress

3/8" holes are drilled through the slab and injection ports inserted



Project Case Study Cont.

Repairs included:

- Drilling 5/8" diameter holes on a 4' on center grid formation through 18" thick shotcrete foundation wall
- Several types of hydro-active grouts were injected through the holes



Grout Creates a “Curtain” Behind Concrete



The Repair of Failed Garage Cost Over \$3M



Polyurethane grout injection 2' on center at a cost of \$35/SF

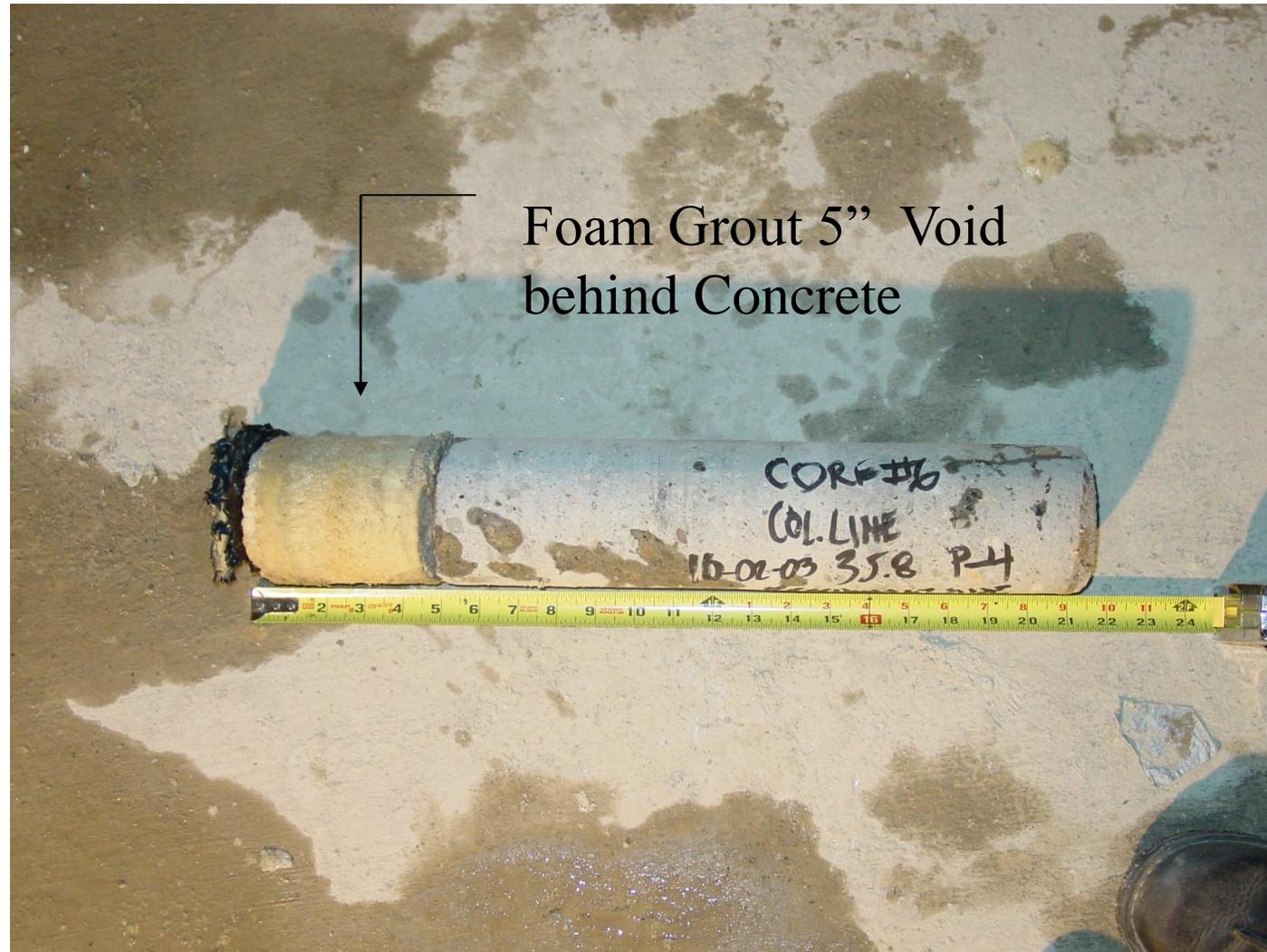
Typical Injection Equipment



Concrete Cores Were Taken To Assess Performance

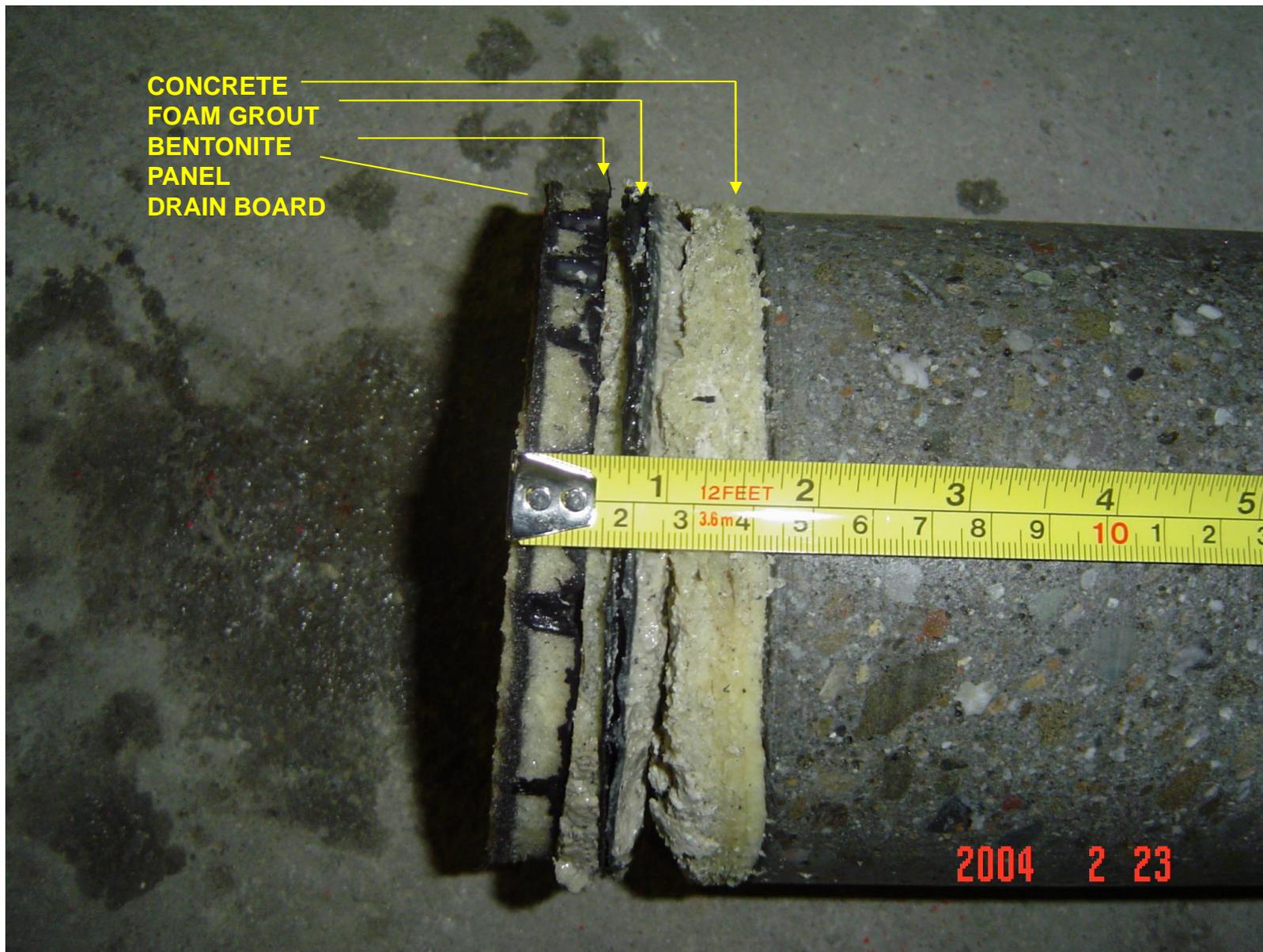


Cores Showed Large Voids Behind Shotcrete



What Caused the Voids Behind Shotcrete?





Voids were present on both sides of the retaining wall and ranged from 1" thick to up to 4" thick.

Site was Excavated to Forensically Analyze Failure



Wood Lagging Issues with Bentonite



Excavation of the soil behind the wood lagging revealed that once the wood gets wet, it swells, bends and twists, especially if there are voids between the soil and wood.



Conventional Wood Lagging



Void behind foam protection board

Voids and Lack of Confinement = Failure



Void between solder pile and foam protection board was also evident and may have contributed to the failure of the bentonite waterproofing system.

Lessons Learned from Failure

- Bentonite requires confinement to work
- Wood lagging can have gaps and voids in the behind it which can allow lagging to move back
- Wood twists and cups when it gets wet, leaving voids
- Protection board at solder pile left voids and potentially reduced the system's effectiveness

Project Case Study Cont.

- Grout Characteristics
- Quickly expands and cures upon contact with water to form a water barrier behind the surface of the wall and under portions of the slab
- Designed to fill an voids behind foundation wall
- Upon reaching maximum confinement, grout continues to internally expand thus increasing in density, pressure and makes foam closed cell and waterproof

Project Case Study Cont.

- Case Study Conclusion
- Potential factors in failure
 - Cast-in-place concrete
 - Lagging
 - Soil consolidation
- Care must be taken to fill voids behind lagging to ensure good consolidation
- Lessons learned – led to change in manufacturers specifications

- Mahalo
- Questions?