



Building Envelope Technology Symposium

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Performance of Weather Resistant Barriers in Stucco Assembly

Karim P. Allana, PE, RRC, RWC

Allana Buick & Bers, Inc.



Presentation Outline

- How does cement plaster work?
- Water management in cement plaster
- Sources of water behind plaster
 - Control joint
 - Window and other openings
 - Plaster itself
 - Private Decks and roof diverting water behind plaster
- Performance of plaster mix design
 - Rilem tube tests
- Performance of Grade D Building paper
 - Pines color damage maps
 - OSB damage tests
 - Drying effects in moisture diffusion to interior
 - Options for upgrading paper

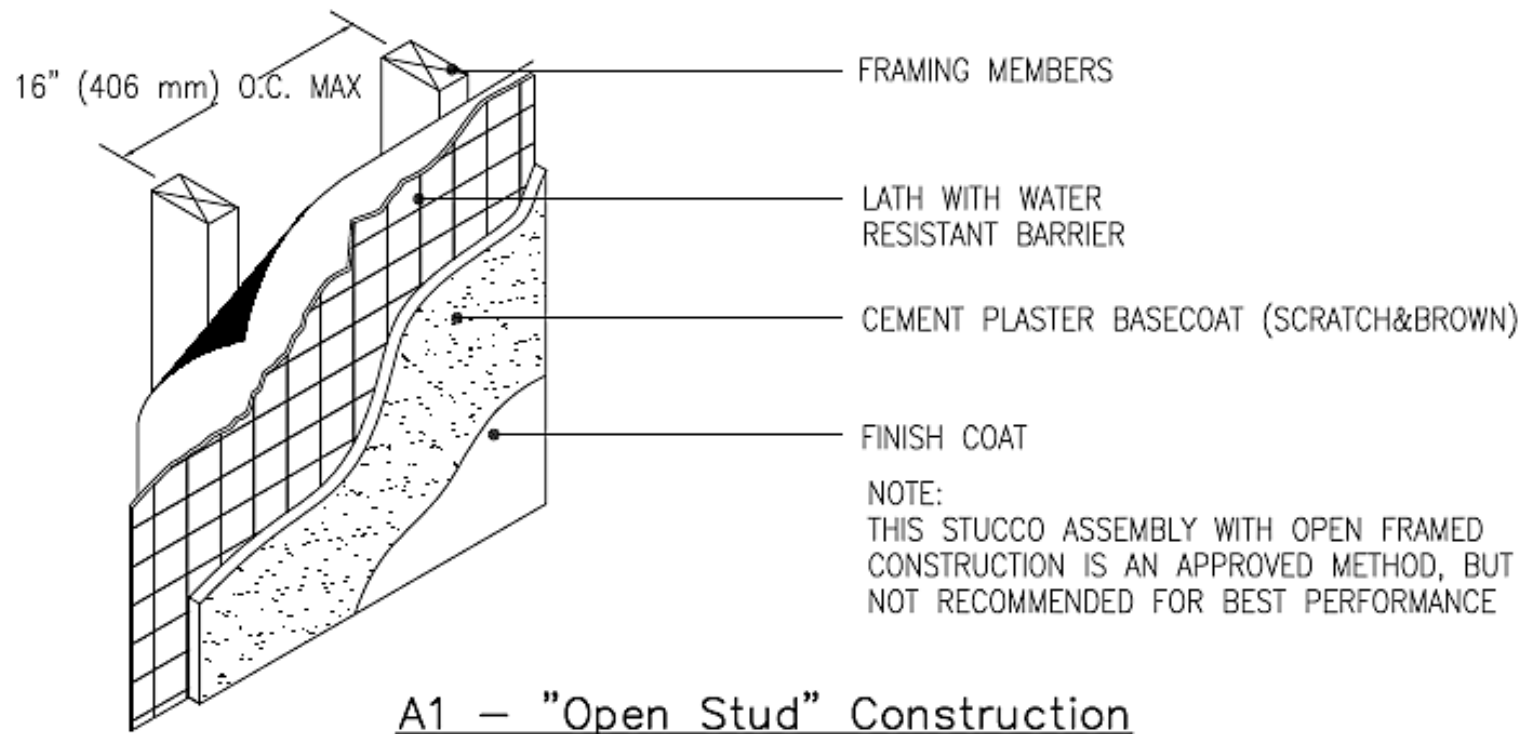


How Does Cement Plaster Work?

Stucco Assemblies

Stucco Wall Assemblies

NOTE: THESE ASSEMBLIES INDICATE ONLY THE BASIC COMPONENTS



Exterior Wall Systems

3 Options For Walls To Manage Water

- Barrier / Face Sealed
- Drainable
- Rain Screen



Barrier vs. Moisture Management

BARRIER / SHEDDING / FACE SEALED

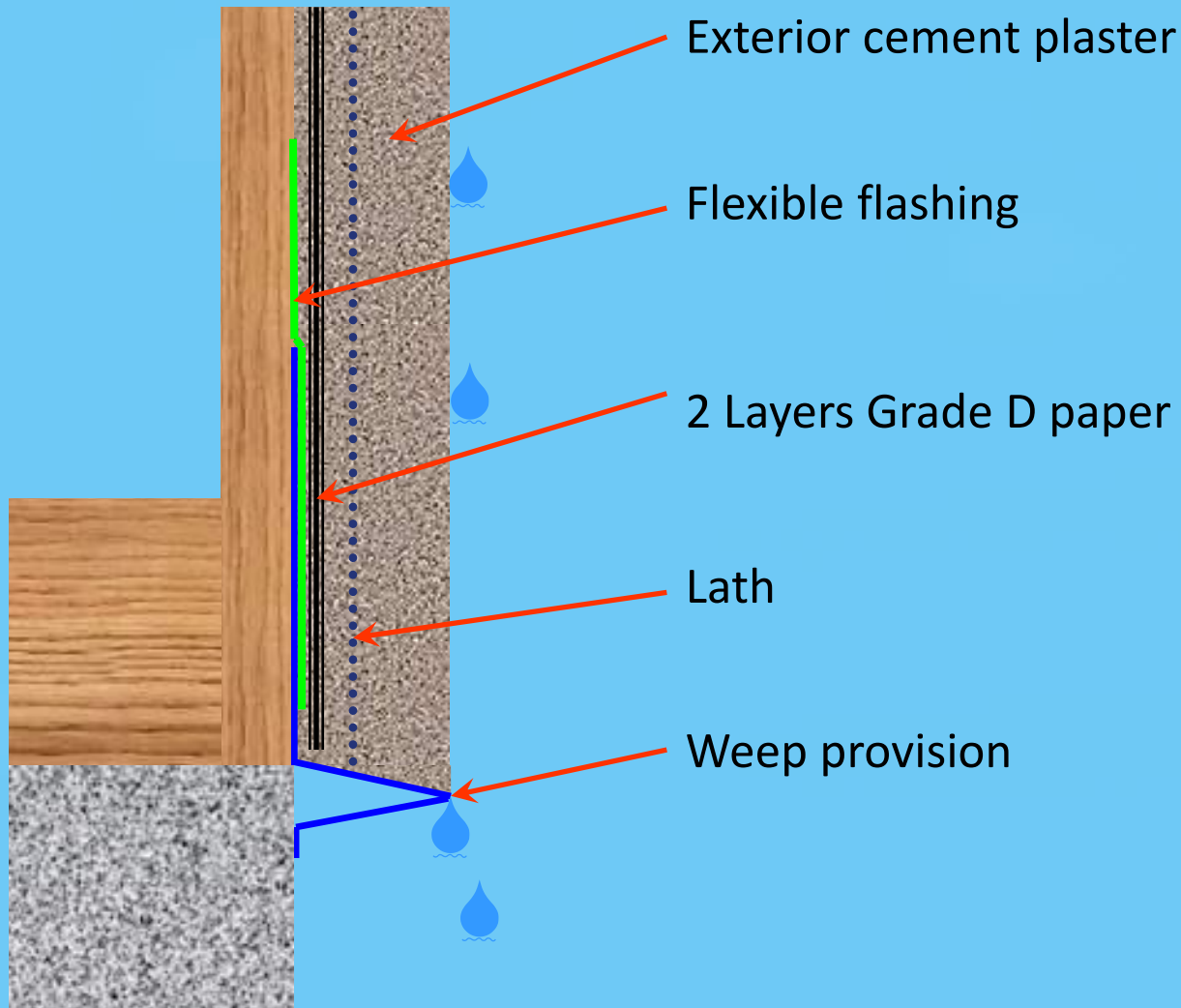
- Exterior surface is the primary means of excluding water from entering the barrier wall system
- Interior waterproofing elements are secondary to the surface barrier
- Expects the water shedding surface barrier to be perfect
- Represents the vast majority of pre-cast concrete, GFRC, curtain wall systems

MOISTURE MANAGEMENT/ RAIN SCREEN

- Exterior surface is the initial means of excluding water from entering the wall system
- Interior waterproofing elements work in tandem with the exterior skin
- Water admitted into the system is captured and managed through weather resistive barrier
- Rain Screen Provides “Air Flow and Better Drainage”



Cement Plaster, Moisture Drained System



Moisture Management Wall – Rain Screen

Rain Screen Drainage System

- Concealed barrier systems with air space for ventilation and drainage
- Most of the water is handled by shedding of water from face of cladding, however... relies on weather resistant barrier to handle very small amount incidental water.
- Much greater capacity to handle moisture on the WRB
- Wets and dries quickly, not sensitive to moisture unless drying is prohibited by incorrect placement of vapor barrier
- Quick drying of WRB means very little moisture is absorbed through the wall and diffused to the interior space
- Exterior sheathing and wall cavity stays much dryer and lowers the chance from mold growth and damage



Wall Wetting Mechanism

Ventilated Rainscreen for Improved
Moisture Management

Wall Wetting Mechanisms are Complex

1. Rain

- Absorption (wicking)
- Penetration
- Splash and drips

2. Water Vapor

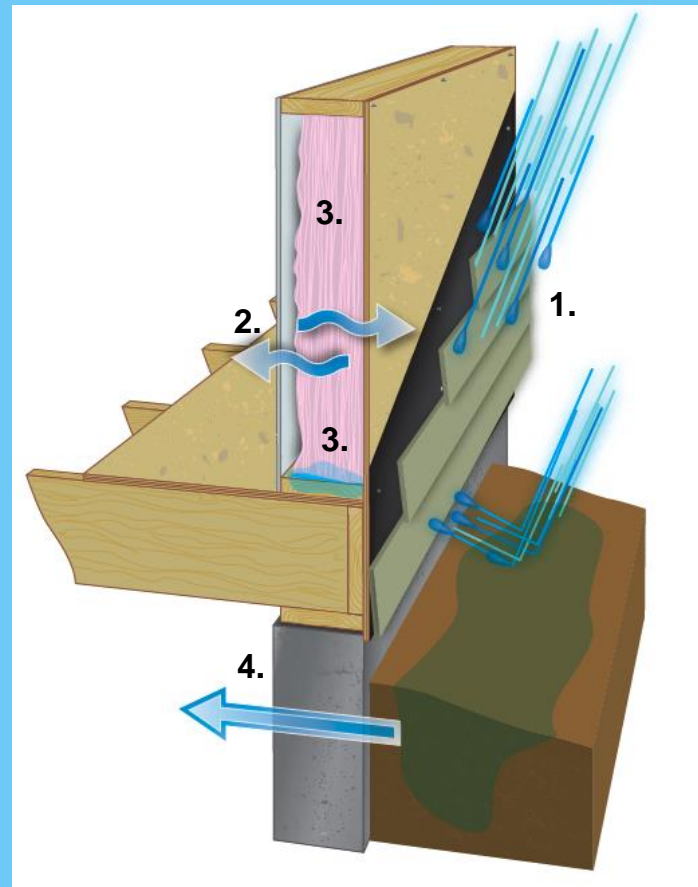
- Diffusion
- Convection (air leaks)

3. Built-in Moisture

- Vapor
- Liquid/frozen

4. Ground Moisture

- Capillary
- Diffusion
- Liquid penetration



Sources of Water On WRB

- Control joints
- Window and other openings
- Private decks and roof diverting water behind plaster
- Porosity and absorption through plaster and other siding



Sources of Water Behind Cladding



Water Soaked Through Paper



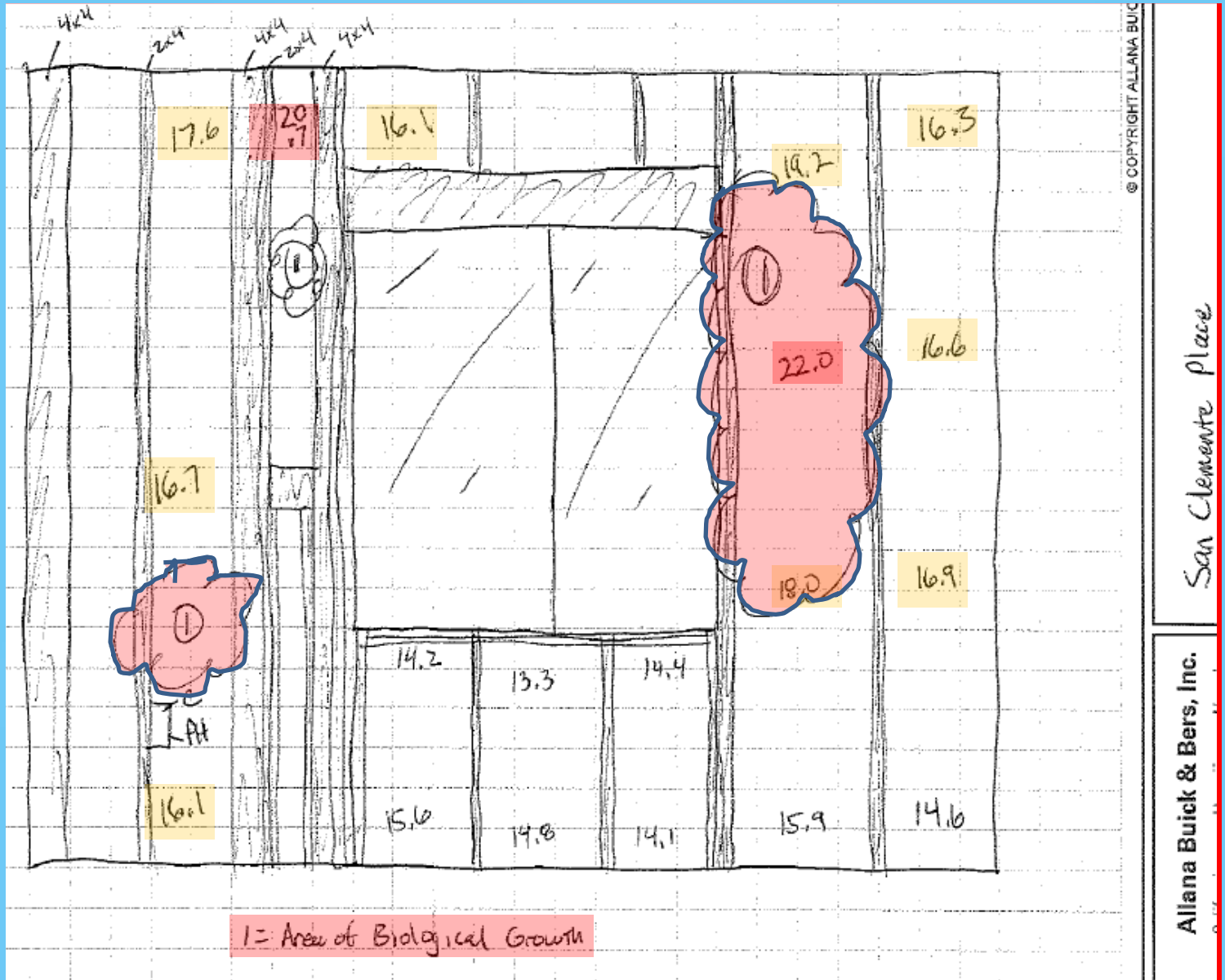
Moisture behind Siding and Stucco



Faster (Shiner)
corroded from
inside



Elevated Moisture Levels Exterior Sheathing



Sources of Water, Corners of Control Joint



ABB2053-134828



Control Joints Nailed Tight To Paper



Sources of Water, Corner Mold at Control Joint



Water Actively Dripping Under Control Joint



WRB is Completely Saturated



Damage from Window Flashing Issues



ID: Window-2104 LR, Unit: 2104, Window, Severe Damage, Peel and stick installed to face of fin and not adhered

Improperly Installed Window Flexible Flashings



ABB2053-20740

ID: Window-2104 LR, Unit: 2104, Window, Severe Damage, Peel and stick installed to face of fin and not adhered



Under Window Damage to OSB



ABB2053-20708

ID: Window-3108, Unit: 3108, Window



Stucco Demo at Handrail Penetration

Test area: Handrail
penetration
At Unit 431 E



Wet and damaged
building paper



High Moisture Content in OSB 24.8%

Test area: Handrail
penetration
At Unit 431 E



Horizontal Areas Of Plaster



ABB2053-03260

ID: Walkway-1406, Unit: 1406, Scupper at Walkway

2010-01-12 Chris Johnson

ABB2053-03260



Highly Absorbent Siding or Cladding

Issues and Problems with highly absorptive claddings and incidental water

Inward Vapor Drive

- Stucco & Adhered Veneers = very high moisture storage
- Wet cladding + undrained water + solar heating = rising vapor pressure
Drives vapor inward!
- Wet blanket effect against building paper



Field Performance Testing South Carolina

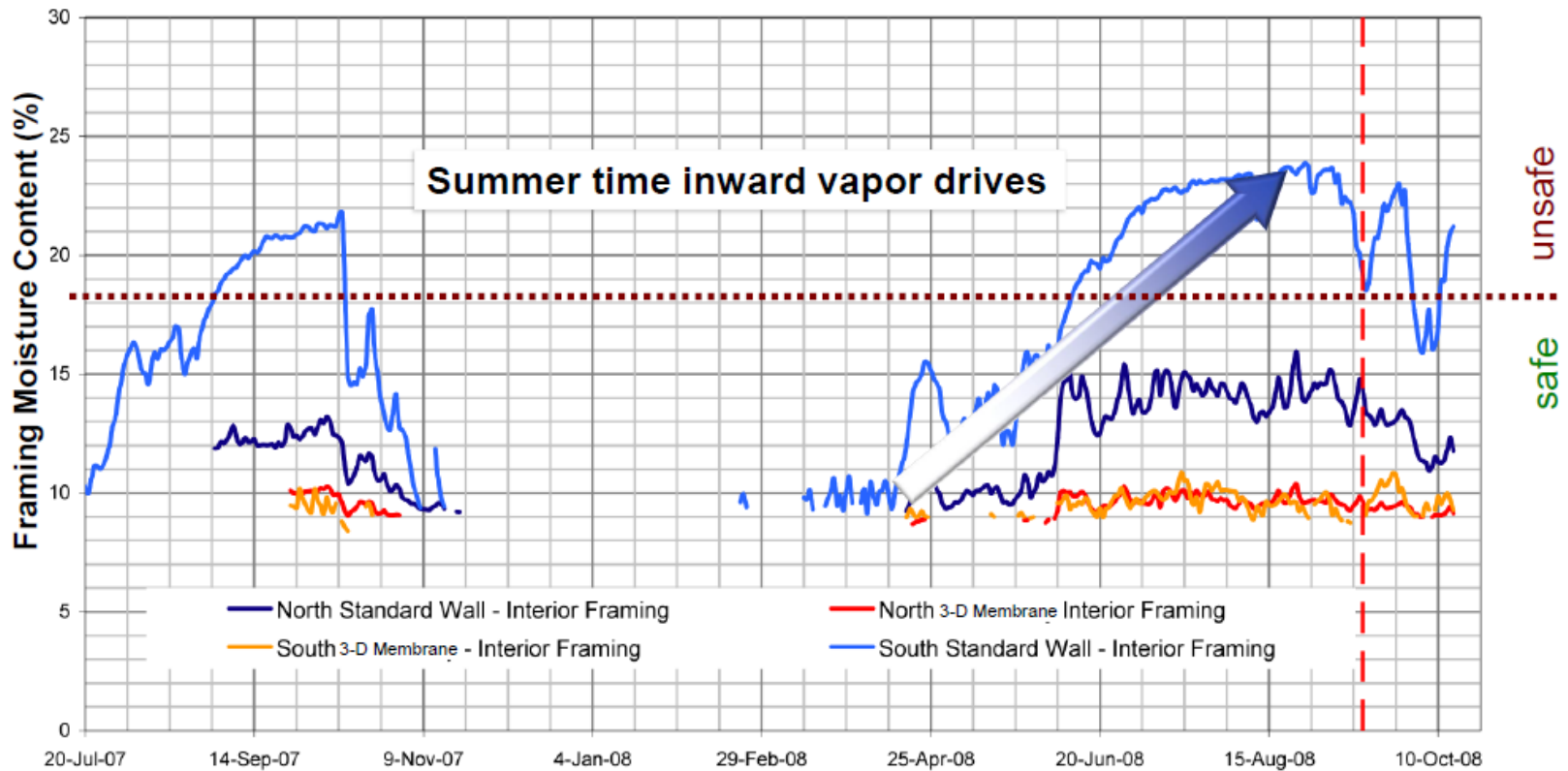


Field performance testing at testhut in Waterloo, ON
Dr. John Straube, Building Science Corporation



Absorption of Water Can Lead To Damage

Framing Moisture Content



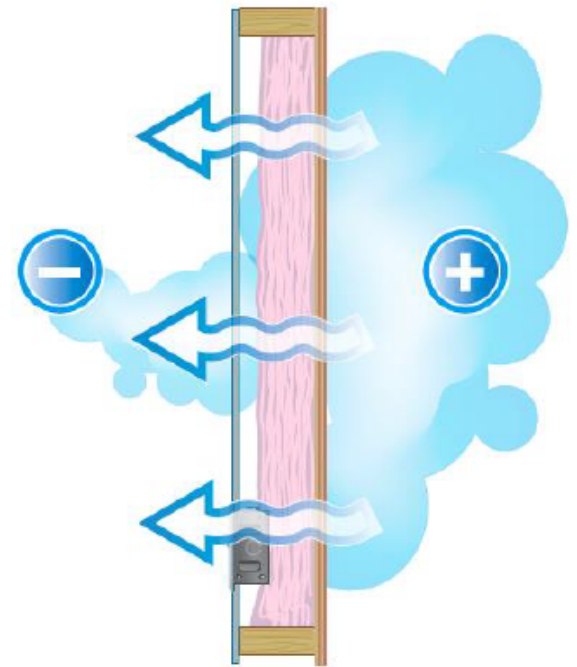
Vapor Diffusion - Permeation

Why Does Vapor Diffusion Occur?

Vapor diffusion is driven by
Vapor Pressure Differentials

If moisture content in air is different inside and outside of a wall, vapor diffusion will occur until the vapor pressure differential is eliminated (equal vapor pressure on either side of the wall)

Resistance to vapor diffusion depends on water vapor permeance of materials
(perm rating)

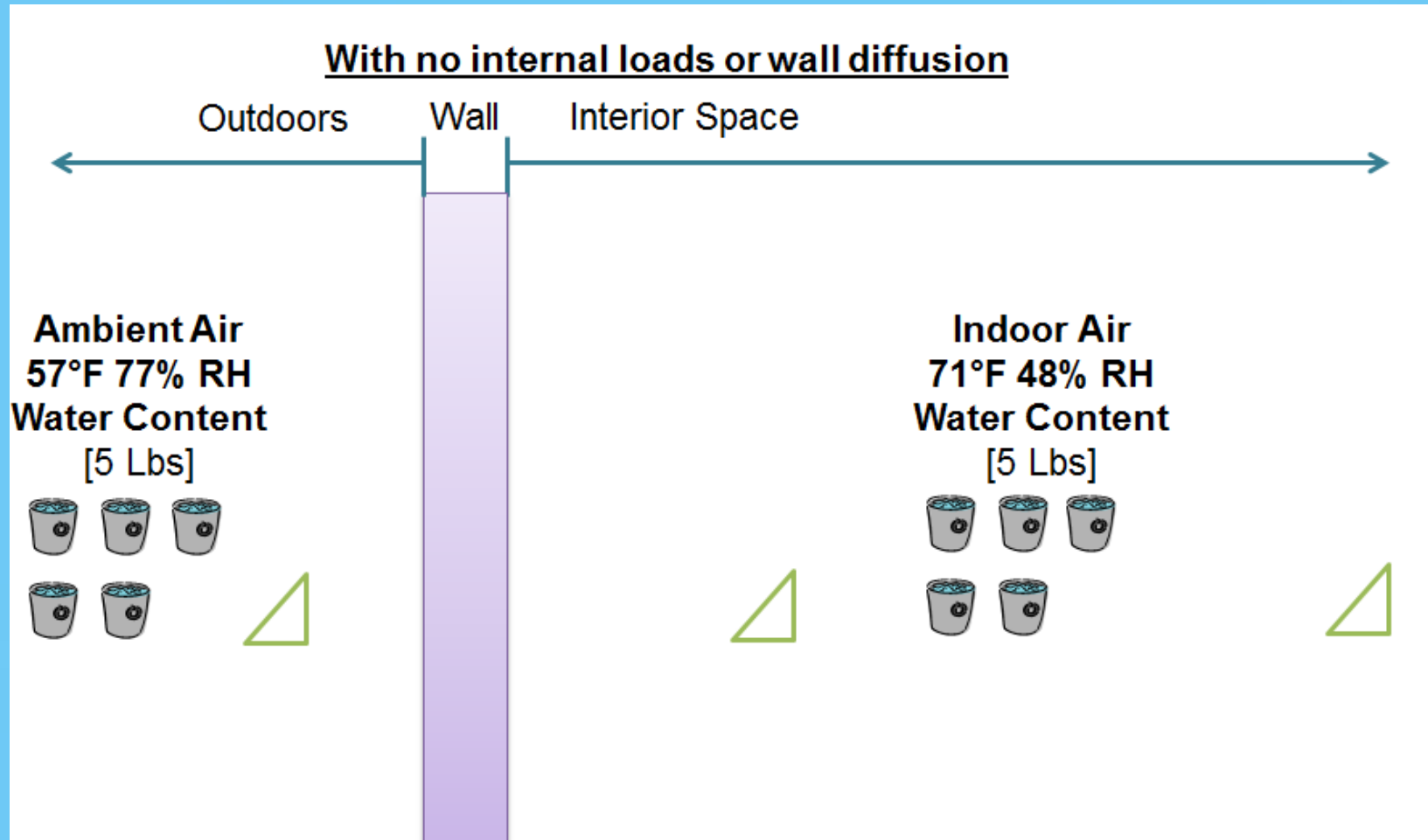


Study of Rising Interior Humidity

- Moisture absorbed through exterior cladding raises humidity inside living spaces
- Verify exterior moisture intrusion is raising humidity as opposed to internal moisture sources (occupant activity).
- The preliminary study based its findings on data collected during routine site inspections. This data was not initially intended for the use of this study.
- Following routine gathering of information, a small number of test units were chosen
- Study was conducted in San Jose, CA during winter in-between periods of rain



Moisture Diffusion Study Results

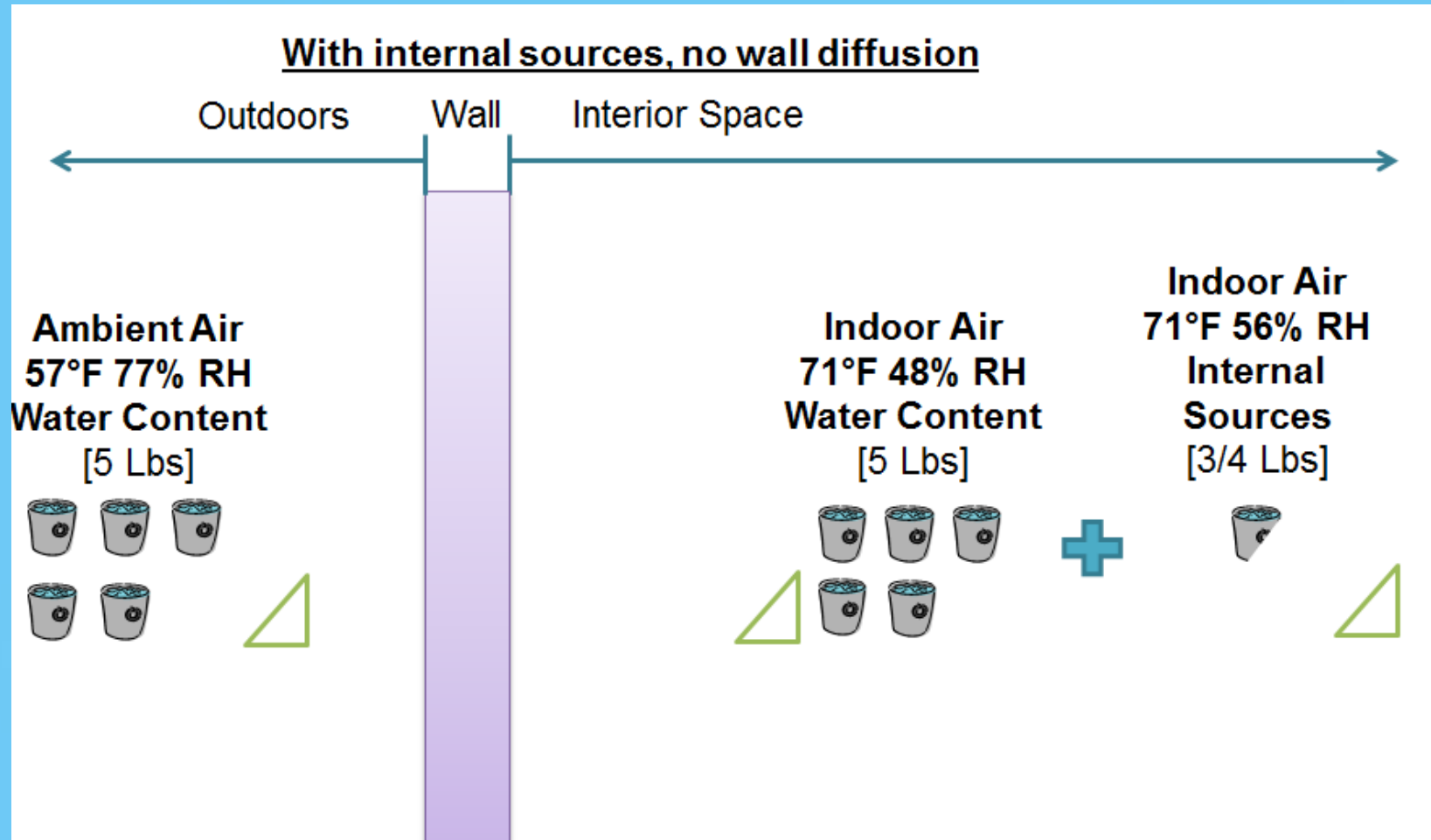


Moisture Diffusion Through Cement Plaster

- **Actual conditions measured in a 2 bedroom residential unit:**
 - 937 sq. ft.
- **Natural ambient air moisture content:**
 - 57°F dry bulb, 77% relative humidity
- **Interior space room conditions:**
 - 71°F dry bulb, 80% relative humidity
- **Internal moisture sources include:**
 - (2) 15 min. showers a day
 - (1) 10 min. boiling pots a day
 - (1) 20 min. hand dish washing
 - 12 hours of person seated at rest
 - 2 hours of person at moderate work
 - 1 hours of person at light exercise

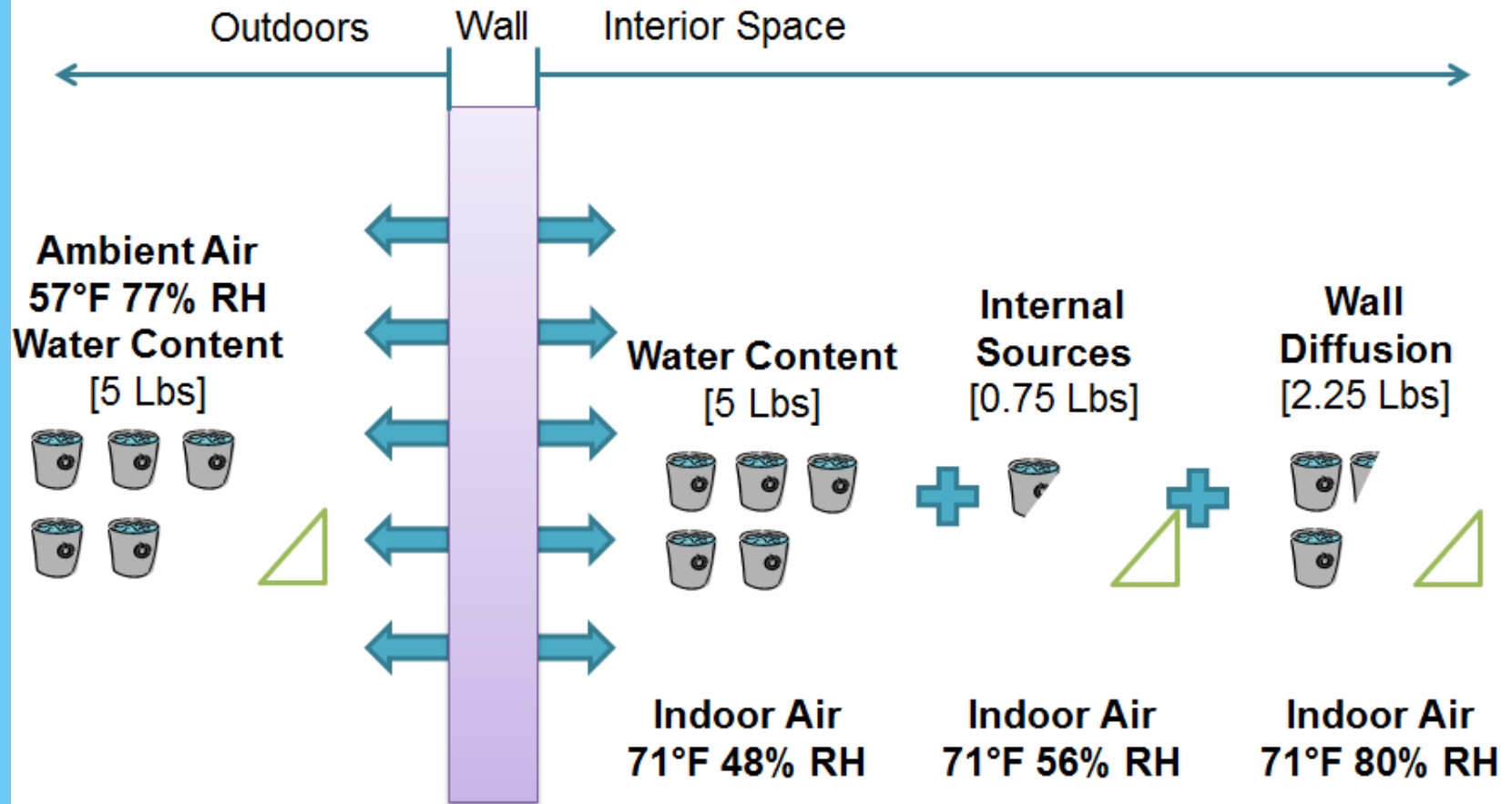


Moisture Diffusion Study Results

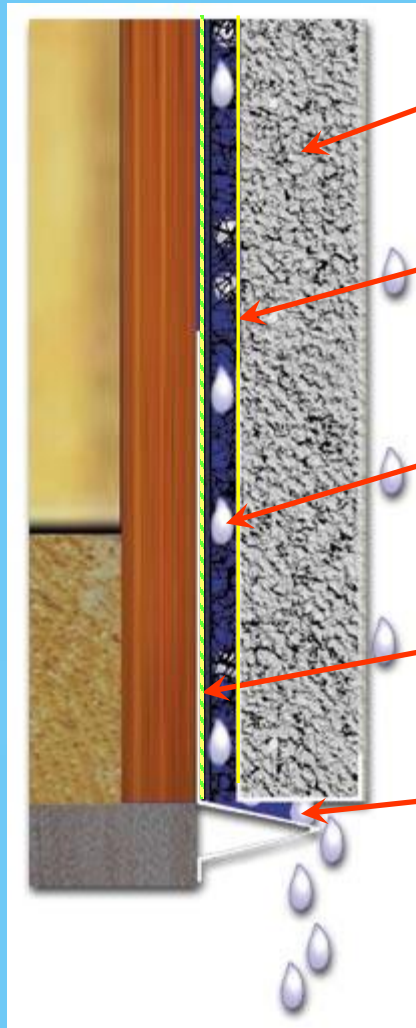


Moisture Diffusion Study Results

With internal sources + wall diffusion due to excessive cracking and defects



Moisture Management System With Drain Mat



Exterior cement plaster

Outboard moisture barrier

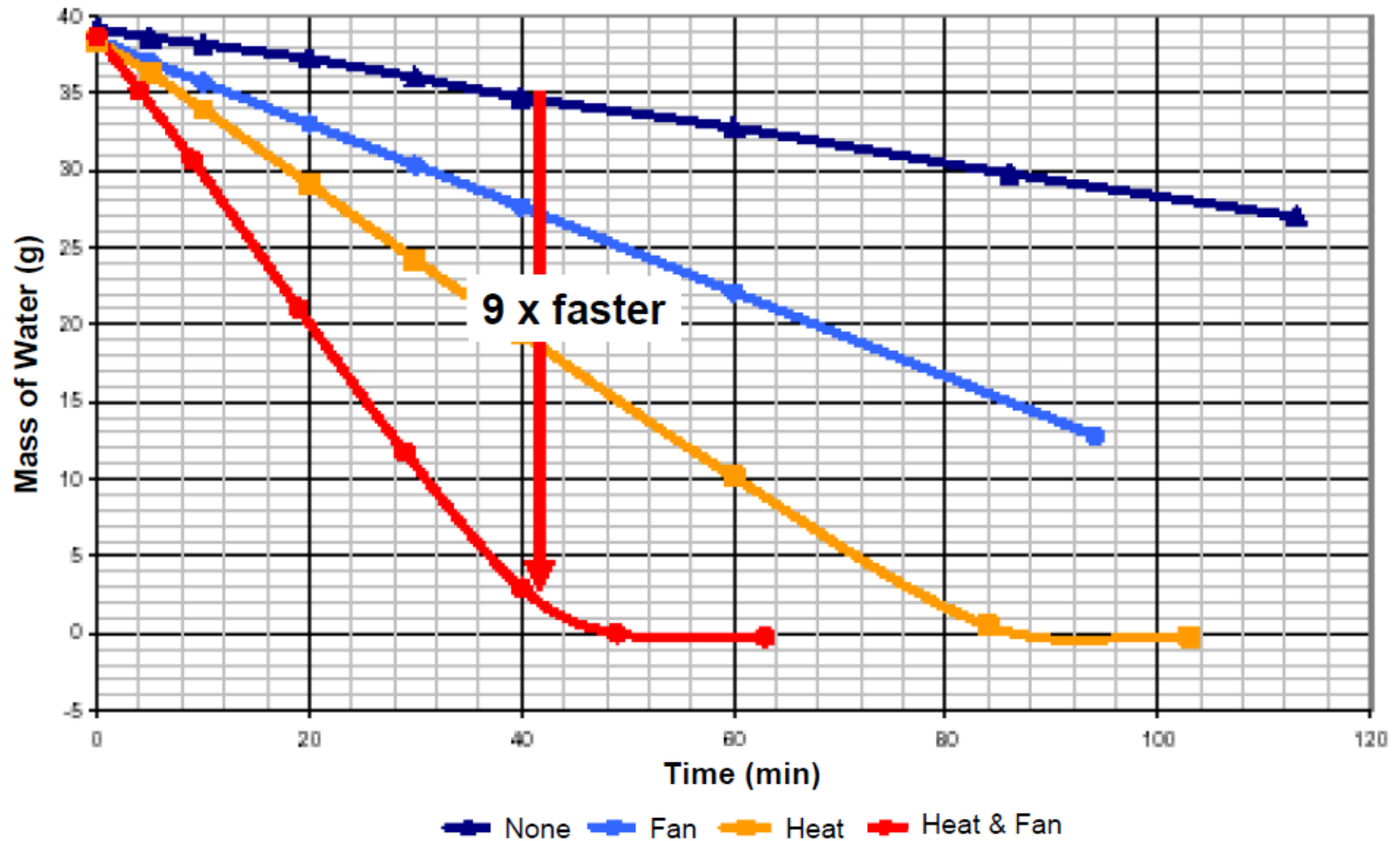
Drainage cavity

Inboard moisture barrier

Weep provision

Paper Towel Wetting Analysis (Dr. Straube)

Comparison of different Drying Techniques on Paper Towel Wetting



© Dr. J. Straube; Westford Symposium '06



Performance of Plaster Mix

Absorption through cladding can add significant moisture

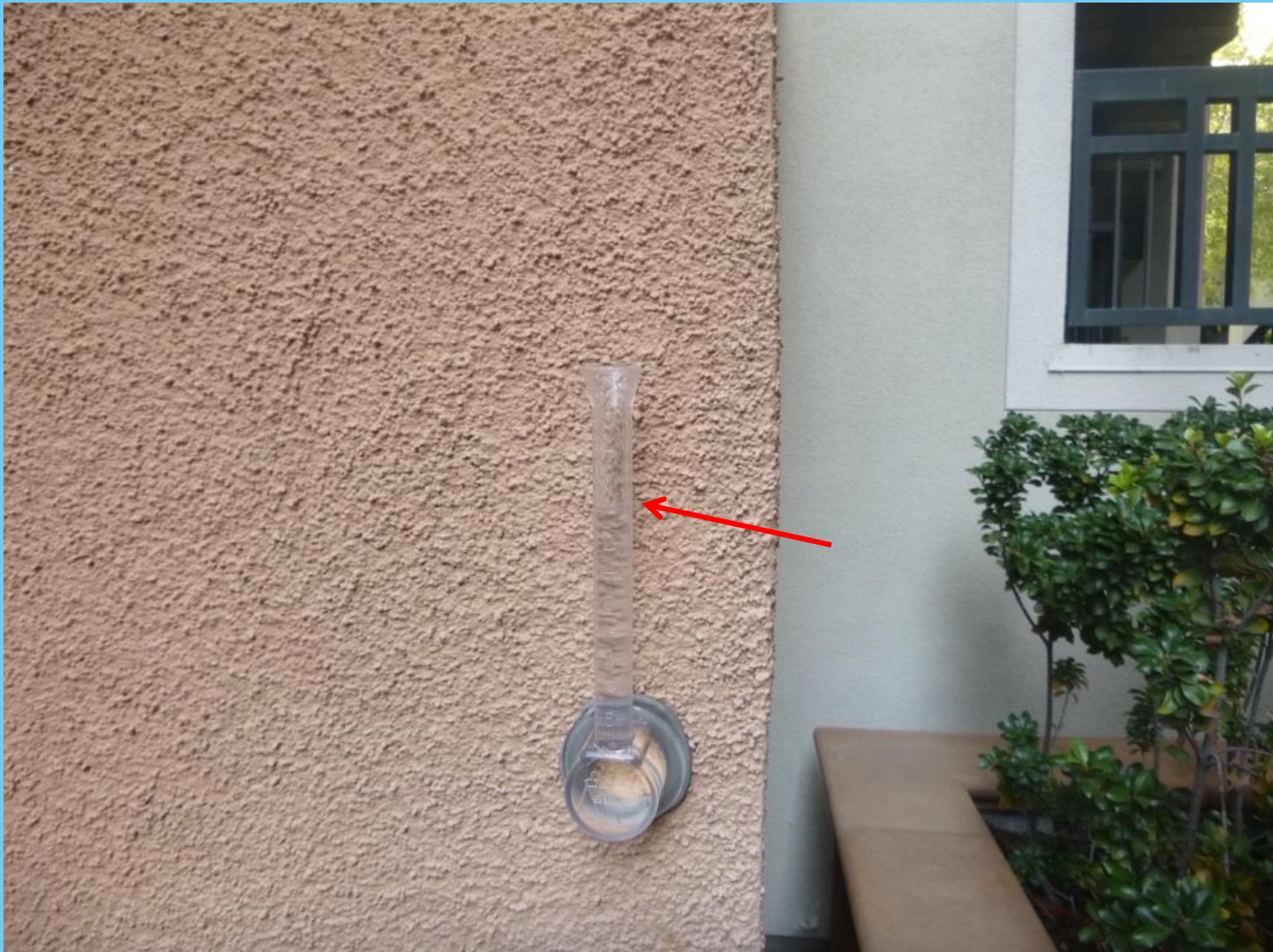
Rilem tubes - used to test water absorption rate

Results:

- **Pines B-2**
 - 11/18 locations significantly lost water = 61%
- **Pines B-1 STO Finish**
 - No locations lost water
- **Pines B-1 BMI Stucco**
 - No locations lost water



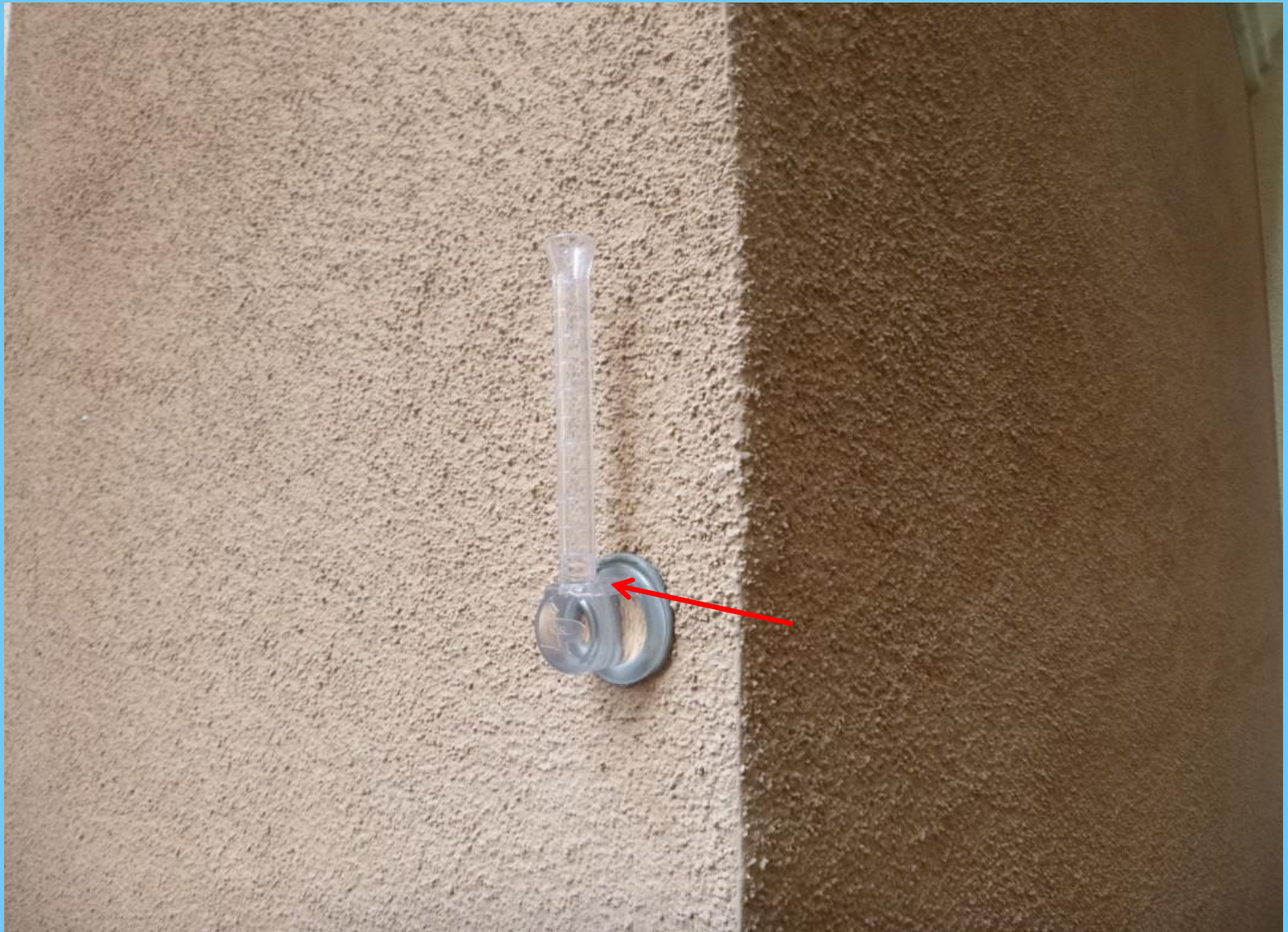
Pines B2 - Water Dropped Almost Immediately



Building 4-Location 8-A. Water dropped to a level almost immediately before we could take a photo of full tube.



End of Test – In 15 Minutes



Building 4-Location 8-A. Water dropped to bottom of circular body of the tube near the end of the test.

End of Test – In 15 Minutes



Building 3 Location 6-A, full Rilem tube



Rilem Tube Level Dropped in 15 min



Building 3 Location 6-A, water level at end of test.

STO Finish - End of Test –Tube Full



Building Pines B-1 Bldg. 1 Unit 1111 Rilem test over new Sto Finish-Tube is full at end of test.



Pre-Mix Stucco - End of Test –Tube Full






Building Pines B-1 Bldg. 2 Unit 2110 Rilem test over new BMI stucco-tube is full at end of test.





Damage – San Jose Apartment– South Elevation

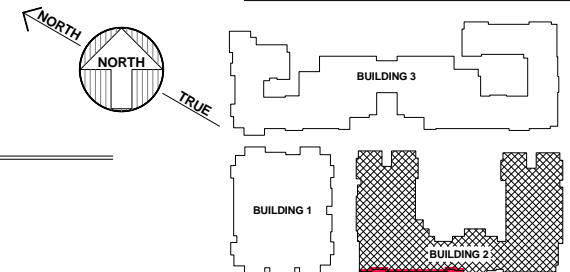


KEY - TYPE OF DAMAGE

	Slight:	Water Stains
	Moderate:	High Moisture Content
	Severe:	Decay / Rot

 Cracks
 Control Joint

SITE KEY PLAN



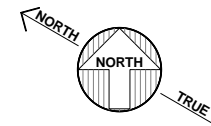
Damage - San Jose Apartment South Elevation



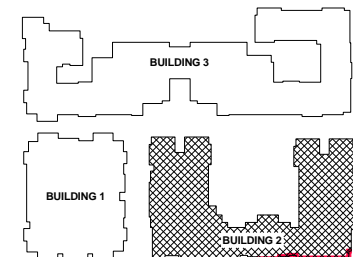
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— Control Joint



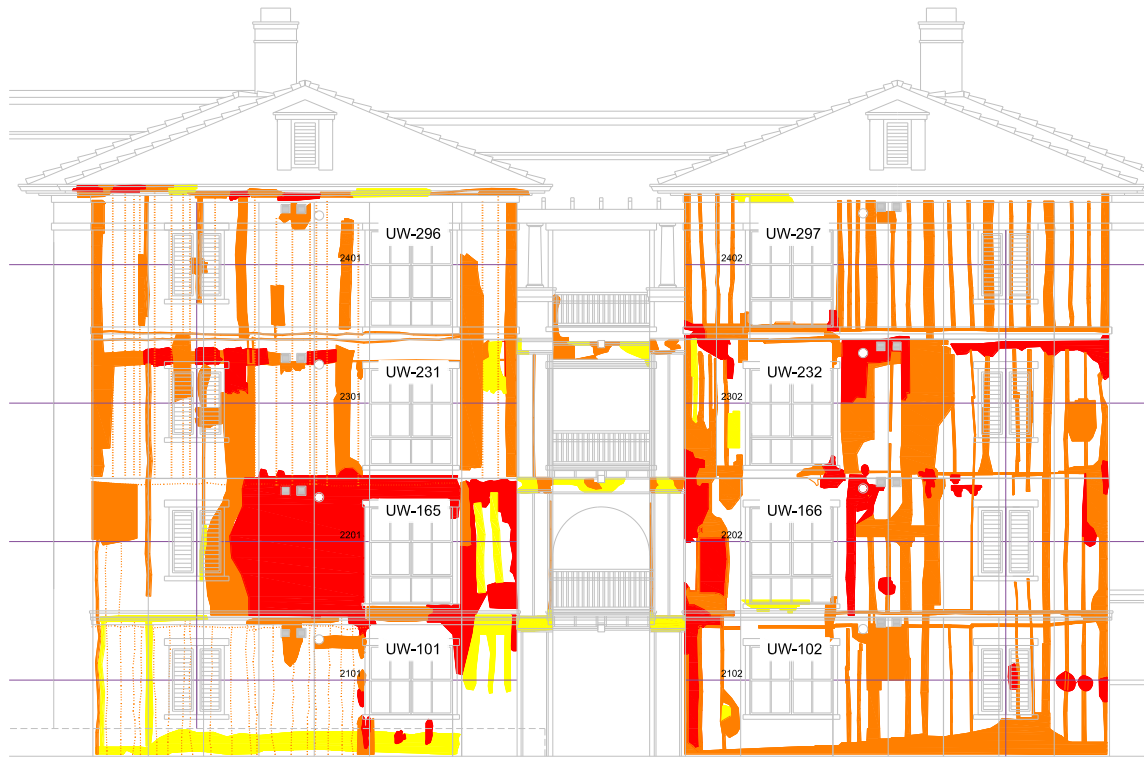
SITE KEY PLAN



Damage - San Jose Apartment North Elevation



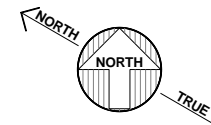
Damage - San Jose Apartment North Elevation



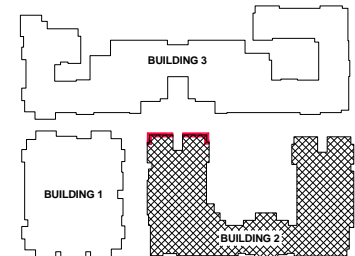
KEY - TYPE OF DAMAGE

Yellow	Slight:	Water Stains
Orange	Moderate:	High Moisture Content
Red	Severe:	Decay / Rot

Blue line Cracks
Purple line Control Joint






SITE KEY PLAN





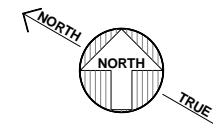
Damage - San Jose Apartment West Elevation



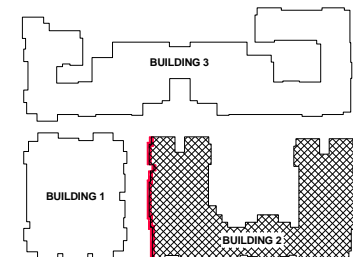
KEY - TYPE OF DAMAGE

	Slight:	Water Stains
	Moderate:	High Moisture Content
	Severe:	Decay / Rot

 Cracks
 Control Joint






SITE KEY PLAN





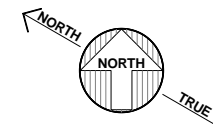
Damage - San Jose Apartment East Elevation



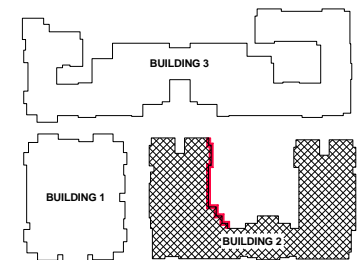
KEY - TYPE OF DAMAGE

	Slight:	Water Stains
	Moderate:	High Moisture Content
	Severe:	Decay / Rot

 Cracks
 Control Joint



SITE KEY PLAN



Damage Ranges From Slight To Severe



Analysis of OSB Damage

Structural Loss of Strength in OSB and plywood wall sheathing can be measured empirically

Damage States Defined

- No Damage
- Slight Damage
- Moderate Damage
- Severe Damage



OSB Damaged State: No Damage



OSB Damaged State: Slight Damage



OSB Damaged State: Moderate Damage



OSB Damaged State: Severe Damage



OSB Damaged State: Severe Damage



ABB2053-23785



Nail Pull Through Strength Test: ASTM D1037



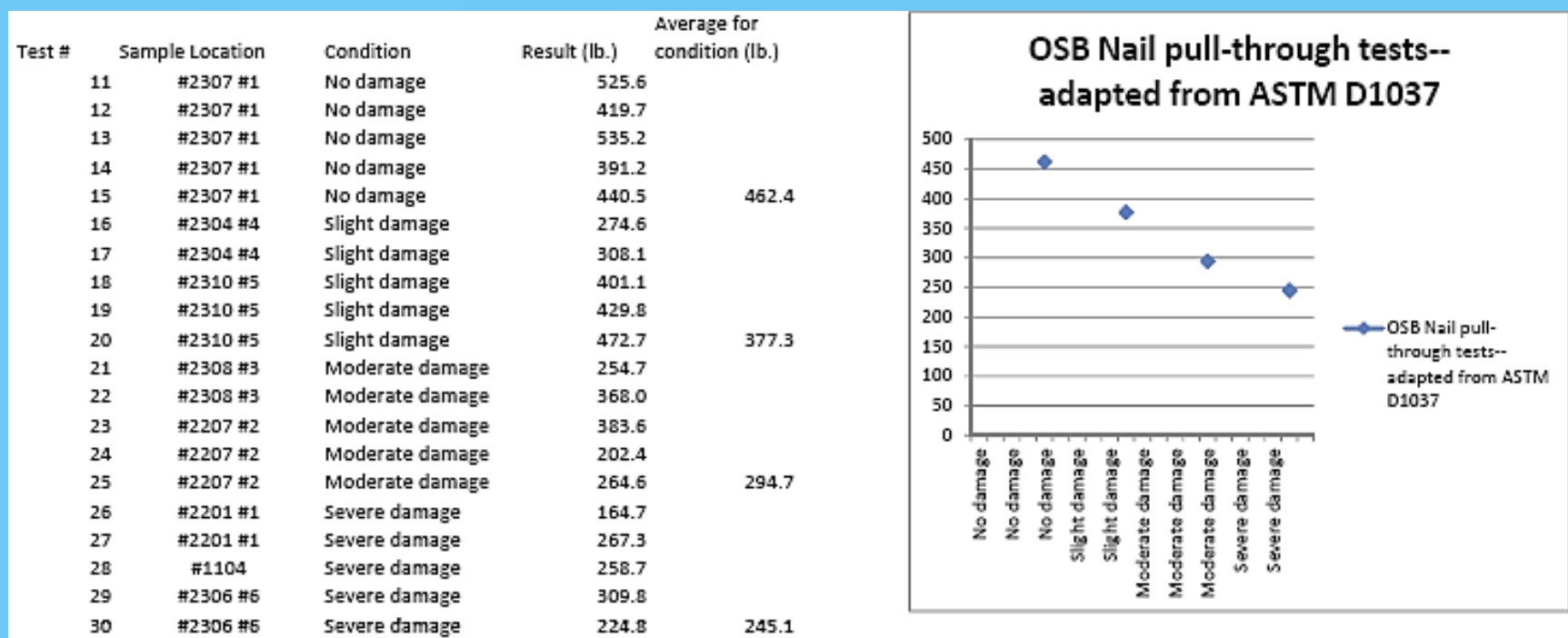
Nail Pull Tests Per ASTM D1037

- ABBAE performed 5 pull tests of each damage state level of Pines OSB Per ASTM 1037
- A Pull Through Test is an indication of loss of strength and structural integrity



OSB Nail Pull Tests – Loss of Strength

Pull through test results are:



2053: Pines Parcel B-1, Tests Performed by Dennis Wobber 10/9/2012

OSB Nail pull-through tests--adapted from ASTM D1037



OSB Nail Pull Tests – Loss of Strength

Water Damaged Panels significantly lose structural strength:

Slight Damage	19% less nail pull out strength
Moderate Damage	36% less
Severe Damage	46-100% less

In shear tests, panels typically fail from edge nail pull out or panel tear-through.

The above results show the projected approximate loss of shear values for each damage level.



Wall Drying Mechanisms

Ventilated Rainscreen for Improved
Moisture Management

1. Surface Evaporation
2. Diffusion / Convection
3. Drainage
4. Air Exchange (Ventilation)

