NWCB
Sustainable Solutions

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Allana Buick & Bers, Inc.
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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

Seminar Objectives – Exterior Envelope

- New building code and construction document requirements
- Shift in responsibilities, scopes of work, and standards
- Wall types and systems and how they differ
- Real facts on building science and properties of materials
- Critical details for the interfacing of components

Seminar Objectives – Exterior Walls

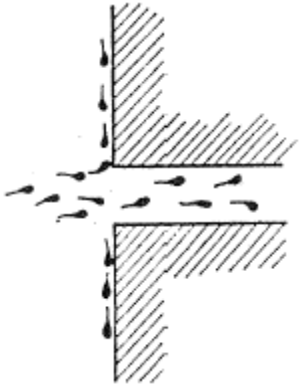
- Exterior wall types and systems and how they differ
- New building code and construction document requirements
- Shift in responsibilities, scopes of work, and standards
- Real facts on building science and properties of materials
- Critical details for the interfacing of components

Exterior Wall Assemblies

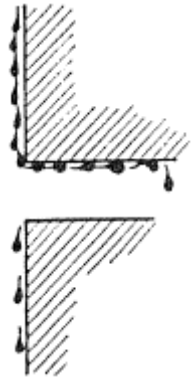
Typical Forces in Nature that Cause Water Intrusion Through Wall Assemblies

•Air Currents

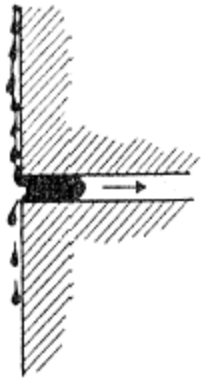
Gravity



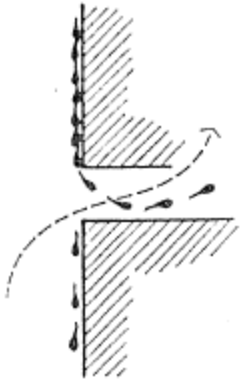
Kinetic Energy

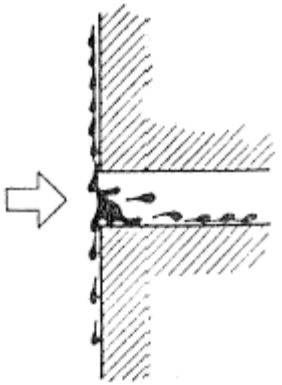


Surface Tension



Capillary Action





Pressure Differential

Exterior Wall Systems

- Exterior Walls Provide Waterproofing in Different Ways

- Three Basic Ways of Managing Water
  - Barrier Wall Systems
  - Drainable Wall Assemblies
  - Rain Screen Principal

BARRIER WALL ASSEMLIES

- When exterior skin/mass is designed to be the only water barrier.
- Examples:
  - Traditional Exterior Insulation & Finish (EIFS)
  - Mass Masonry Walls
  - Some types of Curtain Walls
  - Cast in Place (CIP) Concrete Wall

BARRIER WALL SYSTEMS

Barrier vs. Moisture Management

BARRIER

- *Exterior surface is the primary means of excluding water from entering the barrier wall system*
- *Expects the surface barrier to be substantially perfect*
- *Represents the vast majority of pre-cast concrete, GFRC, curtain wall systems*

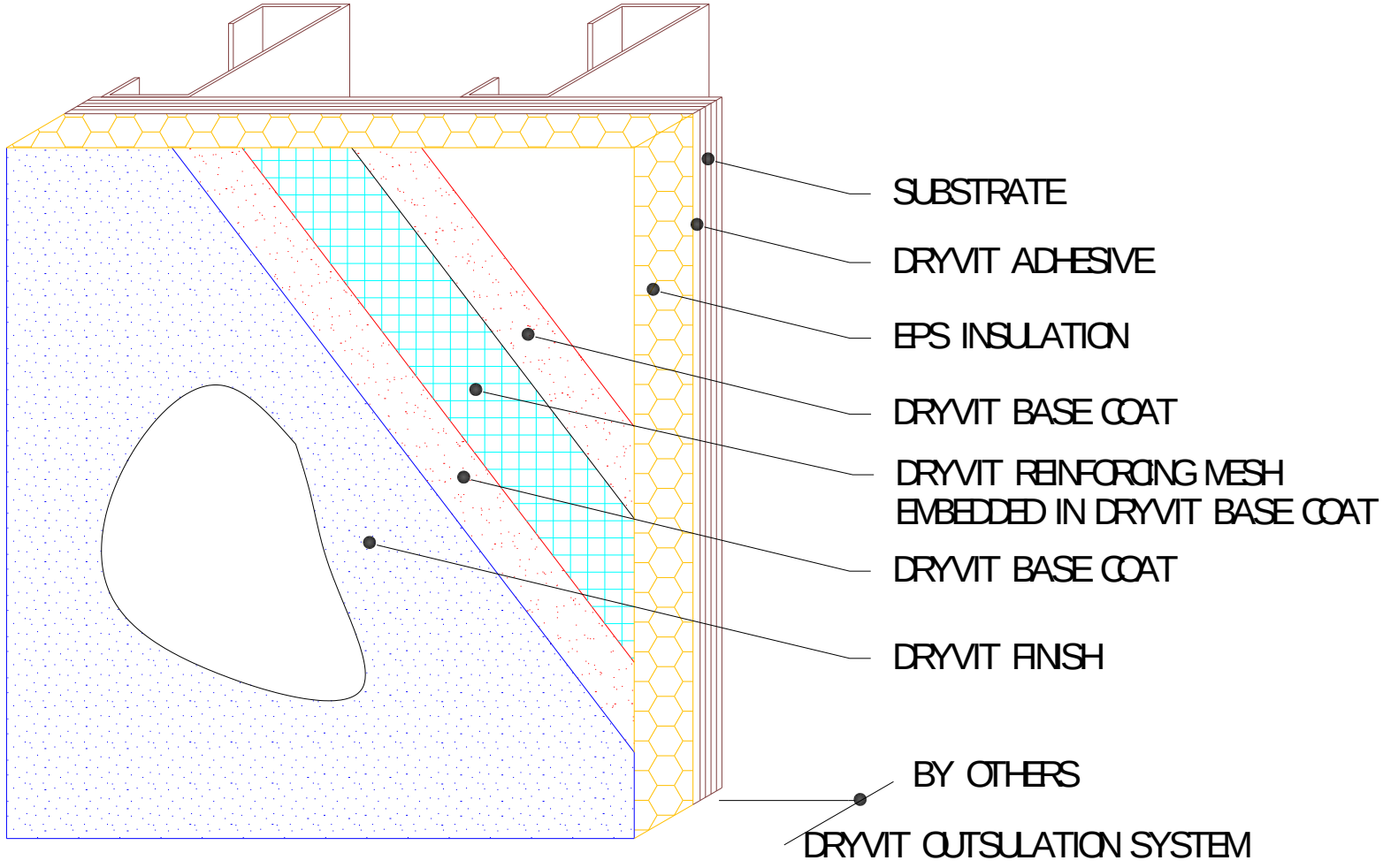
MOISTURE MANAGEMENT

- *Exterior surface is the initial means of excluding water from entering the wall system*
- *Interior waterproofing elements work in tandem with the exterior skin*
- *Accepts that surface barrier is imperfect*
- *Water admitted into the system is captured and managed on weather resistive barrier*

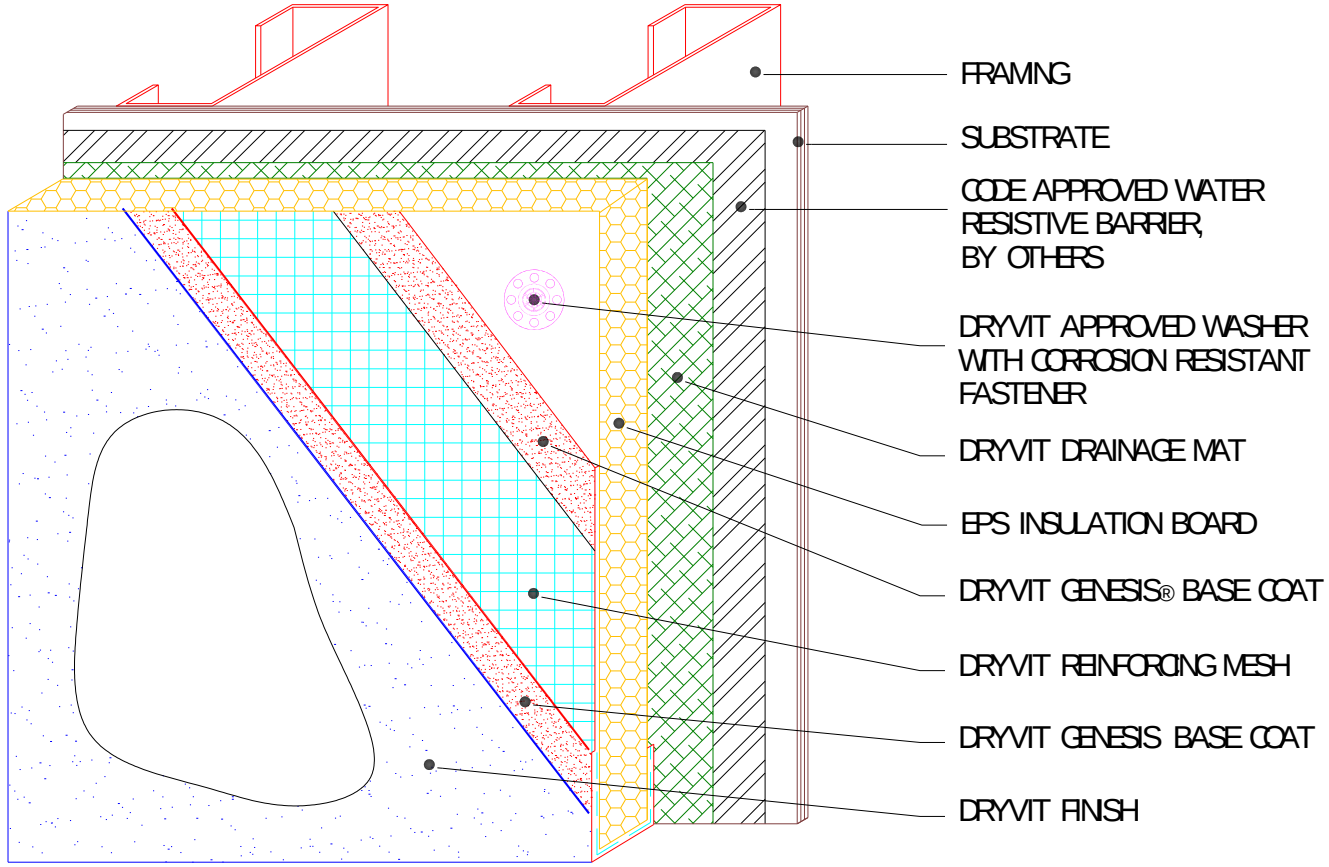
Typical Cement Plaster is a…..

Conventional EIFS

BARRIER WALL SYSTEM

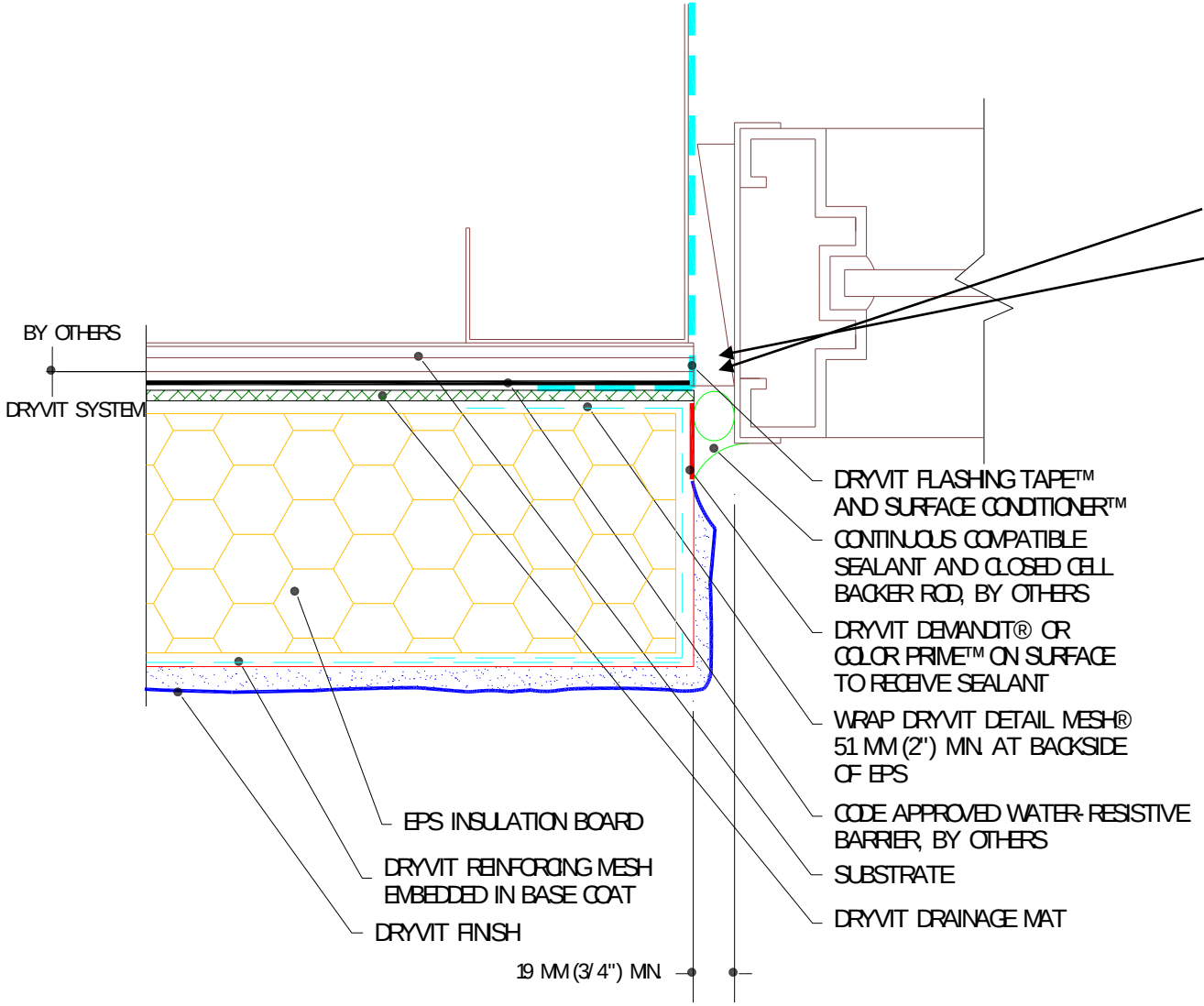


EIFS Moisture Drained System



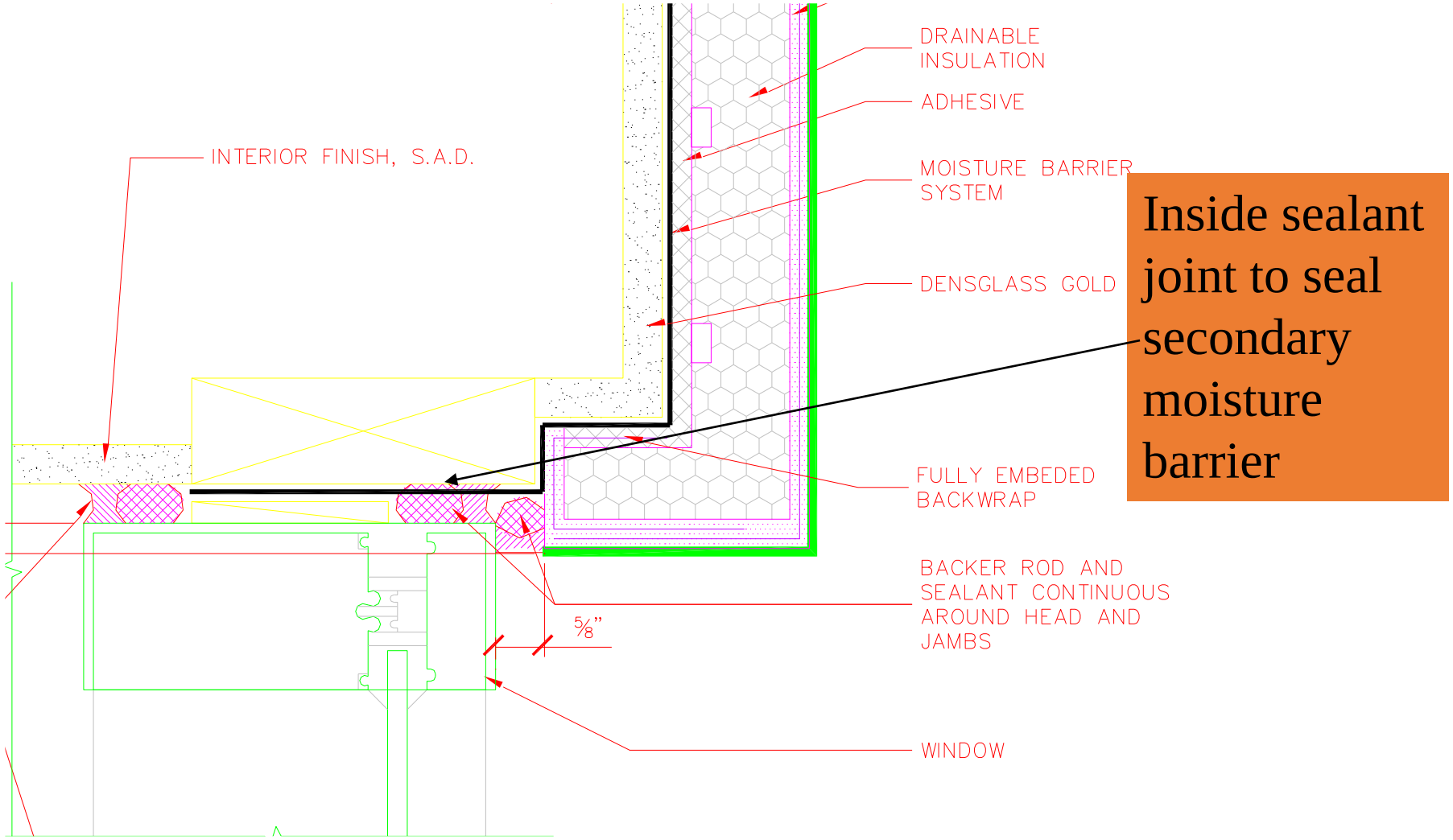
DRAINAGE MAT OPTION
(SYSTEM 1)

EIFS Moisture Drained Window Jamb



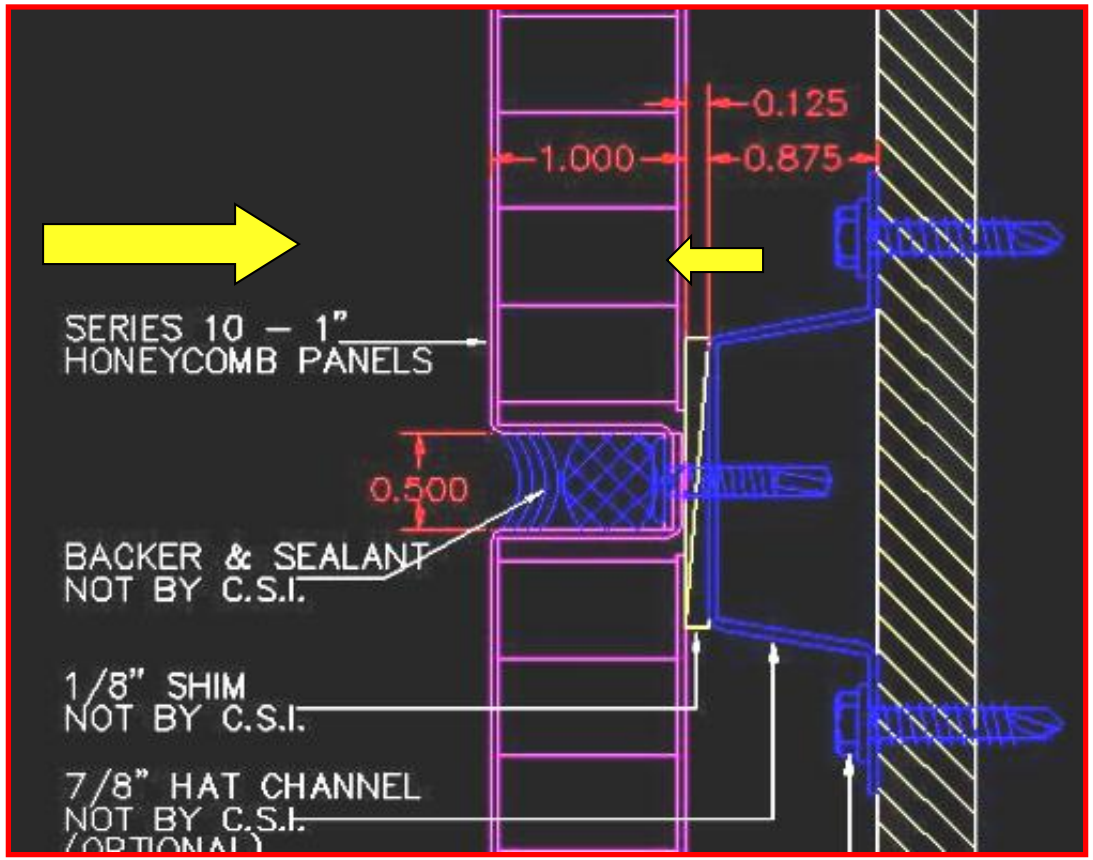
Manufacturer's standard Detail is Missing Secondary Seal to Water Resistive Barrier

Drainable EIFS Window Jamb w/Secondary Seal



Walls Have Pressure Differential

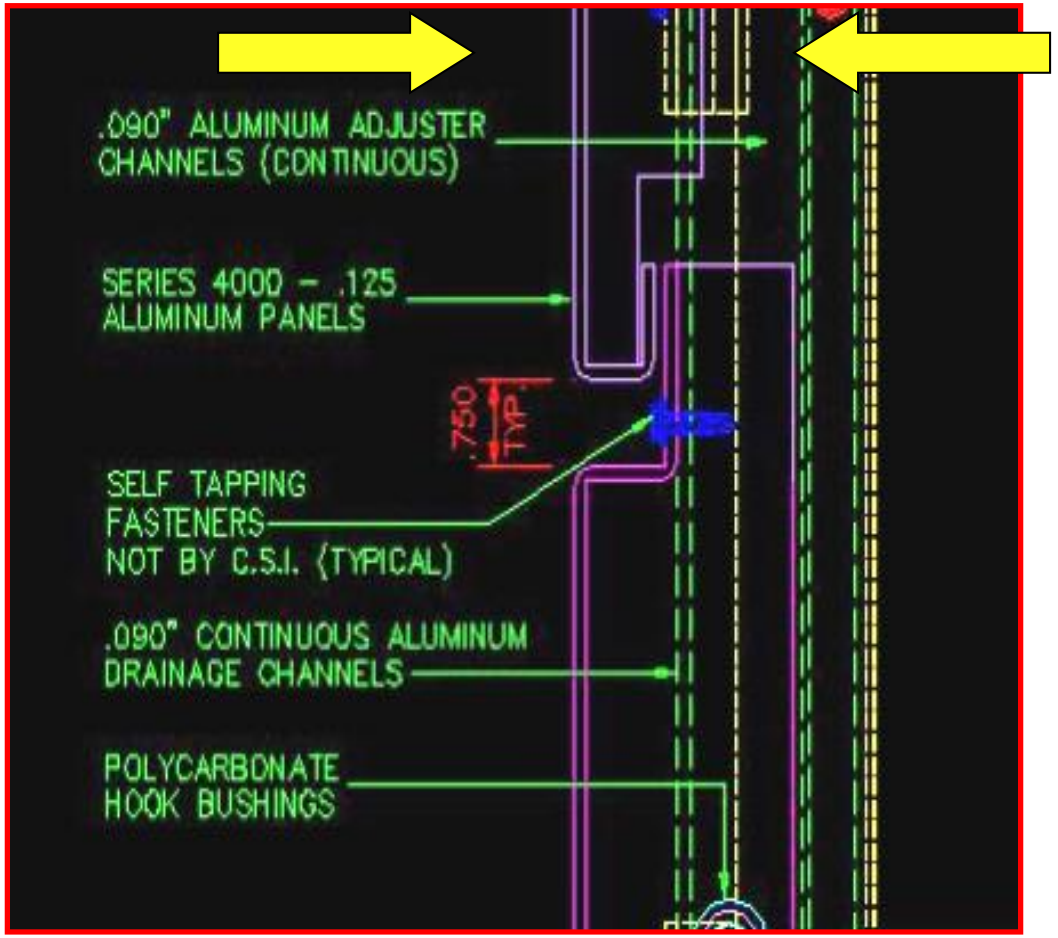
- Cavity Wall
- Wind generates positive pressure on face of wall.
- Pressure is greater on the outside of the wall because it is completely sealed!



RAINSCREEN MINIMIZE PRESSURE DIFFERENCE

"Back Ventilated" Rainscreen Wall

- In a Back Ventilated System the joints are open. Therefore, the pressure on the back side of the panel system is essentially the same as it is on the outside.



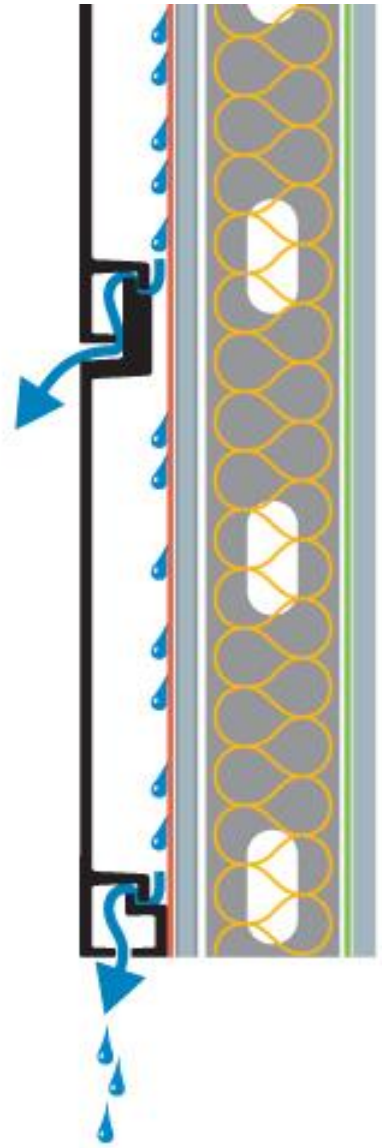
Rainscreen Principles

Water will penetrate the skin – but manage it

Rainscreens allow a wall system to drain liquid and to vent vapor from:

- External leakage
- Internal vapor diffusion
- Internal air leakage

Rainscreens are designed to help drain and dry moisture



Rainscreen Wall Design

Philosophy Behind Back Ventilated Rainscreen Systems :

- Generally not Curtain Wall
- Exterior sheathing with weather resistive and air barriers
- Counteract the driving force behind water intrusion, i.e. Pressure Differential
- Equalize the pressure between the outside skin and inside face of panel
- Cavity behind the panel or masonry with vents to equalize pressure

Exterior Wall Code Changes 2006 IBC Code Upgrade from 1997 UBC

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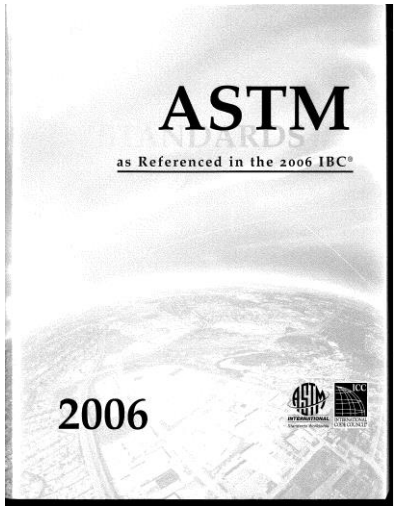
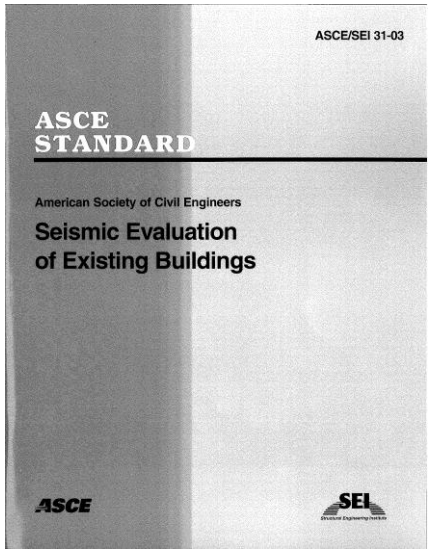
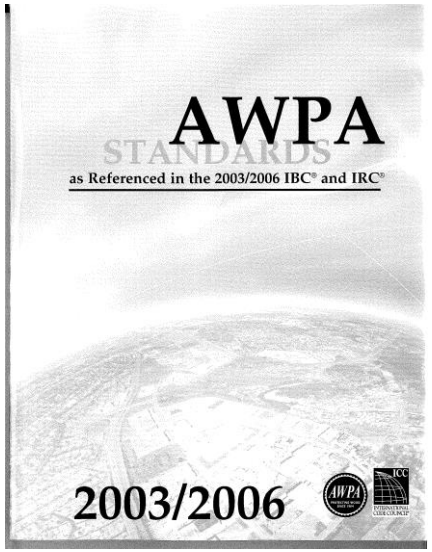
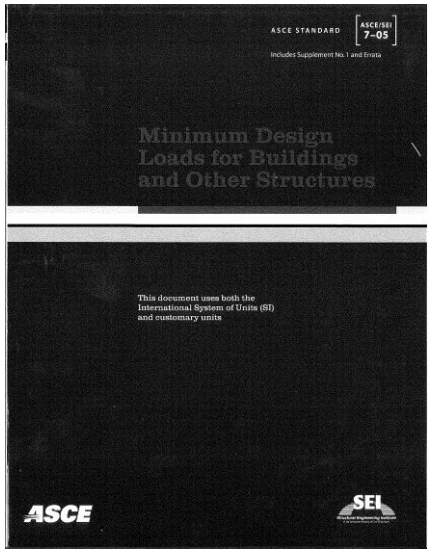
Sample 2007 CBC Code Standards









2006 IBC
500 referenced standards, such as ASTM, NRCA, AAMA, AWPA, AISC...

ASTM reports that are referenced by the IBC 2006 Code include over 1900 pages. The designer and contractor is required to be familiar with all relevant ASTM sections to their project.

Construction Document Requirements for Permit

- 1997 UBC
- Only general drawing submission requirements.

- 2006 IBC
- Section 106.1.3 “Exterior wall envelope.
- …”The construction documents shall provide details of the exterior wall envelope as required, including flashing, intersections with dissimilar materials, corners, end details, control joints, intersections at roof, eaves or parapets, means of drainage, water-resistive membrane and details around openings.”

Construction Document Requirements for Permit

- 2006 IBC
- Section 106.1.3 “Exterior wall envelope. (continued)
- “The construction documents shall include manufacturer’s installation instructions that provide supporting documentation that the proposed penetration and opening details described in the construction documents maintain the weather resistance of the exterior wall envelope. The supporting documentation shall fully describe the exterior wall system which was tested, where applicable, as well as the test procedure used.”

Rainscreen Walls

- 2007 CBC

- 1406.2.4 “Fireblocking. Where the combustible exterior wall covering is furred from the wall and forms a solid surface, the distance between the back of the covering an the wall shall not exceed 1.625 inches and the space thereby created shall be fireblocked in accordance with Section 717.”

Rainscreen Walls

- 1997 UBC
- Mineral wool is not an approved fire block without an approved fire rated sealant.
-
- *At furred rainscreen walls, where fire blocking is required, mineral wool may be used as the fire blocking and still maintain vapor movement.*
- *OR*
- *Provide means of draining the wall every floor*

Rainscreen Walls

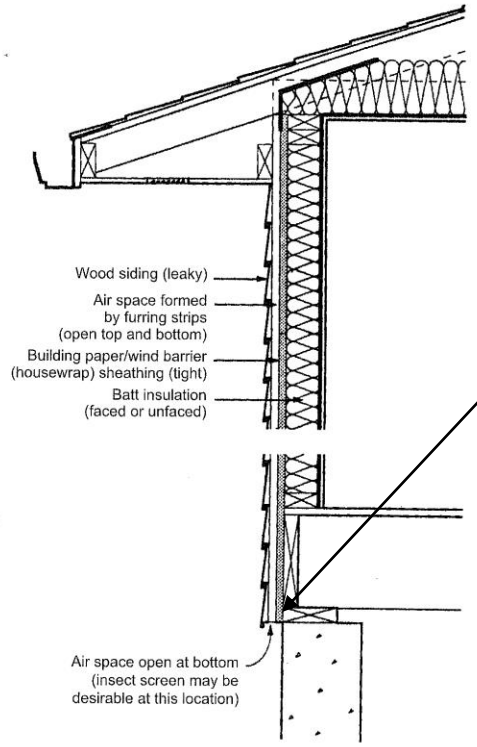


Figure 1—Wood frame wall designed as a rain screen

2006 IBC

Furred rainscreen areas may use mineral wool for fireblocking at floor levels or 10 feet max vertically in multi floor buildings.

Or walls need to be drained at floor levels

Wall Penetrations

- 1997 UBC
- Penetrations though fire-resistive horizontal assemblies shall be enclosed with approved tested assemblies.

- *So how is a ventilation opening put in the ceiling of soffit or deck of a Type V one hour rated apartment building? There were no rated, tested assemblies*.

Penetrations

- *We now have an exception that allows a limited amount of soffit penetrations for ventilation*.

- <u>2006 IBC</u>
- 712.4.1.1 Through penetrations.

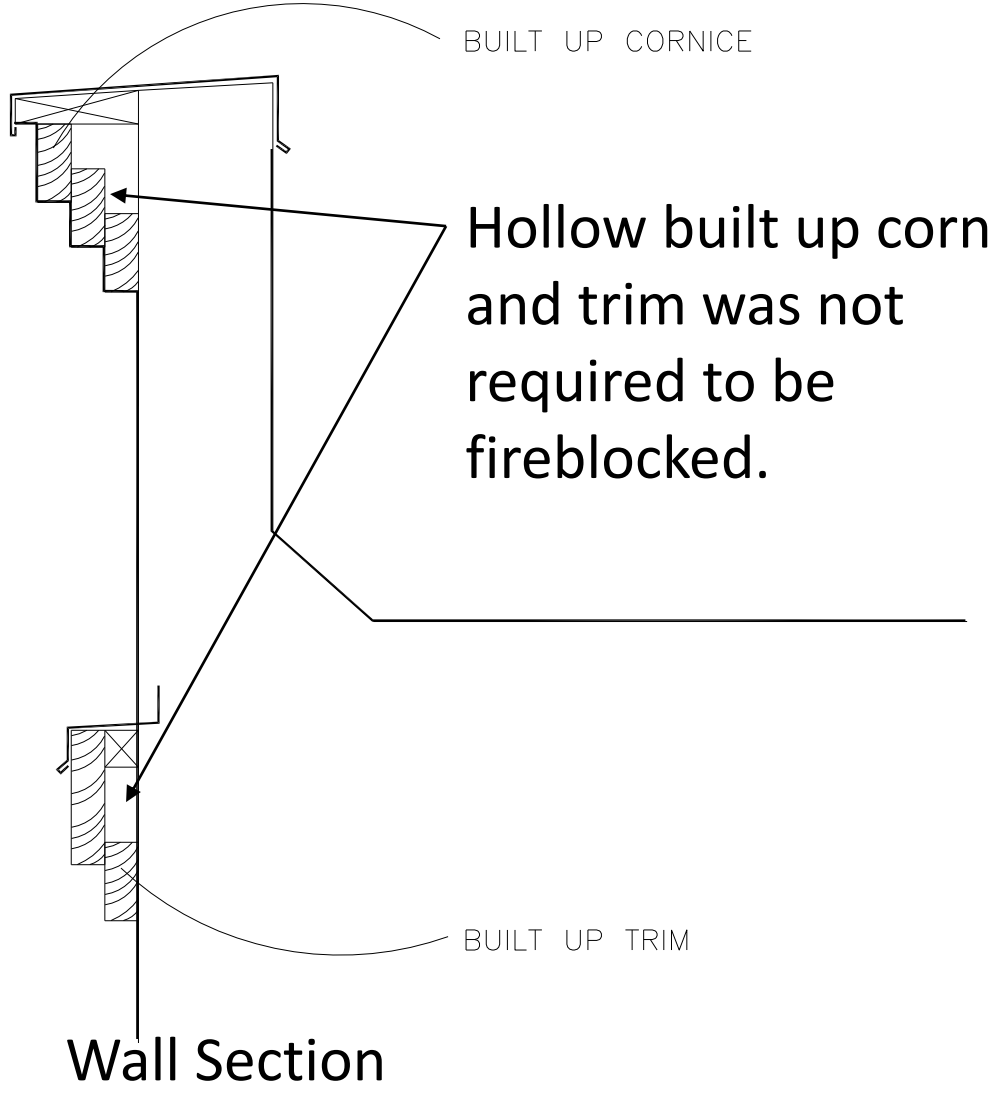
….

"Exceptions: …permitted if "the openings through the assembly does not exceed 144 square inches in any 100 square feet of floor area".

Fire Blocking of hollow trim spaces

- 1997 UBC
- No fire blocking requirement at hollow spaces of built-up units of wall architectural trim or cornices.

Fire Blocking of hollow trim voids was not required



Hollow built up cornice and trim was not required to be fireblocked.

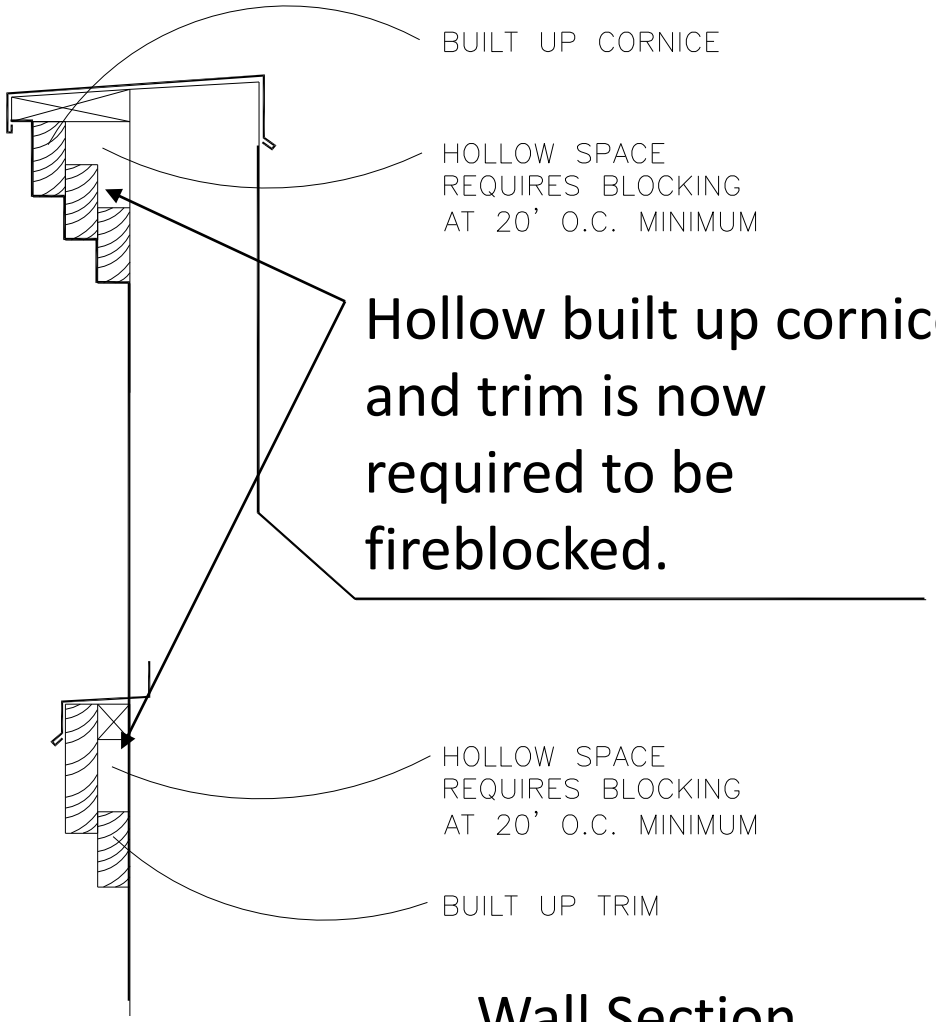
Wall Section

Fire Blocking of hollow trim spaces

- *We have to now fire block hollow cornice spaces.*

- 2006 IBC
- 717.2.6 Architectural trim. Fire blocking shall be installed within concealed spaces of exterior wall finish and other exterior architectural elements where permitted to be of combustible construction as specified in Section 1406 or where erected with combustible frames, at maximum intervals of 20 feet, so that there will be no open space exceeding 100 square feet. Where wood furring strips are used, they shall be of approved wood of natural decay resistance or preservative-treated wood. If noncontinuous, such elements shall have closed ends, with at least 4 inches of separation between sections.

Fire Blocking of hollow trim voids is now required



Hollow built up cornice and trim is now required to be fireblocked.

Wall Section

Weather Resistant Barriers

- 1997 UBC
- 1402.1 "Weather-resistive Barriers. All weather-exposed surfaces shall have a weather-resistive barrier to protect the interior wall covering. Such barrier shall be equal to that provided for in UBC Standard 14-1 for kraft waterproof building paper or asphalt-saturated rag felt. Building paper and felt shall be free from holes and breaks other than those created by fasteners and construction system due to attaching of the building paper, and shall be applied over studs or sheathing of all exterior walls."

- *"Weather-resistive" has never meant "waterproofing". The new 2006 IBC is trying to define weather-ressistive more extensively*

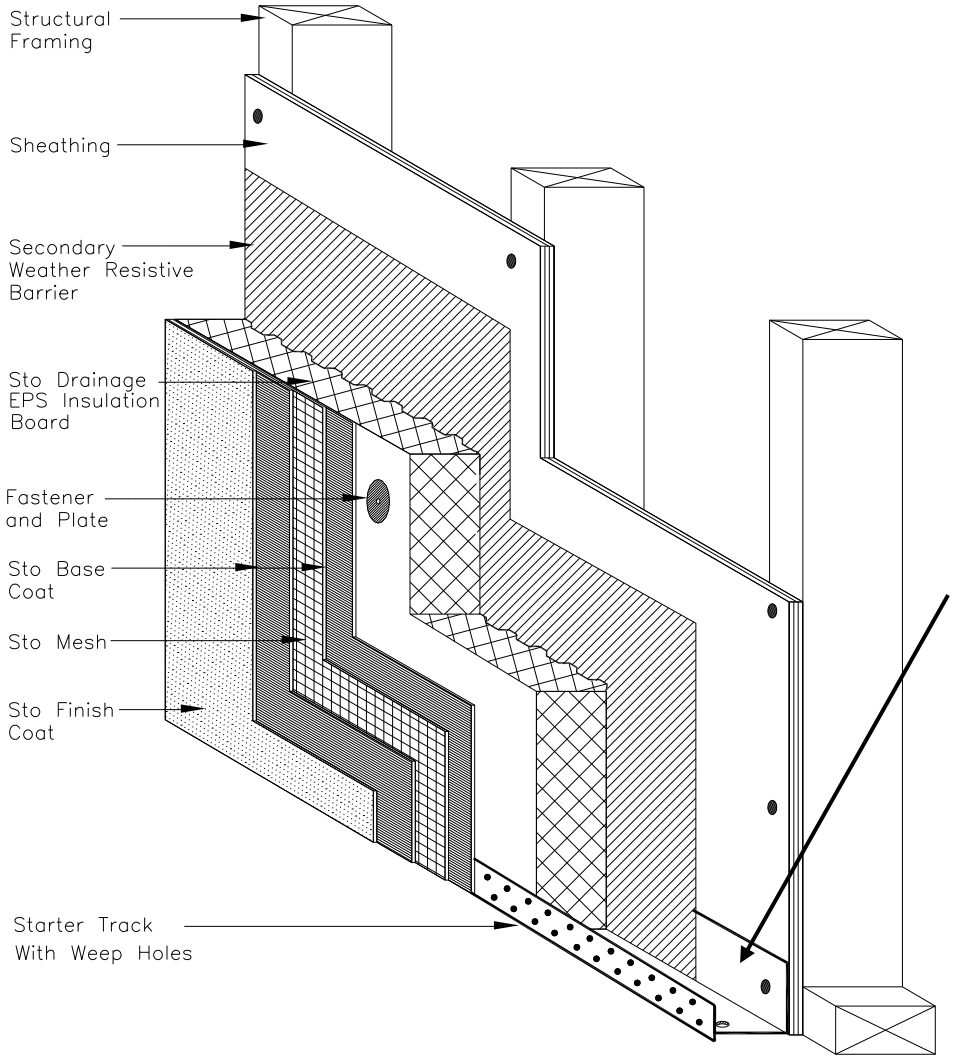
Exterior Wall Require Rain Screen or Drainage

- 2006 IBC
- Section 1403.2 "Weather protection. Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing, as described in Section 1405.3. The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior barrier behind the exterior veneer, as described in Section 1404.2, and a means for draining water that enters the assembly to the exterior."

Exterior Wall, Barrier System Requirement

- Section 1403.2 “Exceptions:
- 1. A weather-resistant exterior wall envelope shall not be required over concrete or masonry walls designed in accordance with Chapters 19 and 21, respectively.
- 2. Compliance with the requirements for a means of drainage, and the requirements of Sections1404.2 and 405.3, shall not be required for an exterior wall envelope that has been demonstrated through testing to resist wind-driven rain, including joints, penetrations and intersections with dissimilar materials, in accordance with ASTME331 under the following conditions: “

All Wall Systems Must have Drainage + Weep



Unless system is tested as a “Barrier System” it must have weather resistive barrier and weep mechanism

2006 IBC Exterior Wall Testing

- Section 1403.2 “Exceptions…
- 2.1. Exterior wall envelope test assemblies shall include at least one opening, one control joint, one wall/eave interface and one wall sill. All tested openings and penetrations shall be representative of the intended end-use configuration.
- 2.2. Exterior wall envelope test assemblies shall be at least 4 feet by 8 feet in size.”

2006 IBC Exterior Wall Testing

- Section 1403.2 “Exceptions (continued)
- 2.3. Exterior wall envelope assemblies shall be tested at a minimum differential pressure of 6.24 pounds per square foot (psf).
- 2.4. Exterior wall envelope assemblies shall be subjected to a minimum test exposure duration of 2 hours.
- The exterior wall envelope design shall be considered to resist wind-driven rain where the results of testing indicate that water did not penetrate control joints in the exterior wall envelope, joints at the perimeter of openings or intersections of terminations with dissimilar materials.”

Weather Resistant Barriers (cont.)

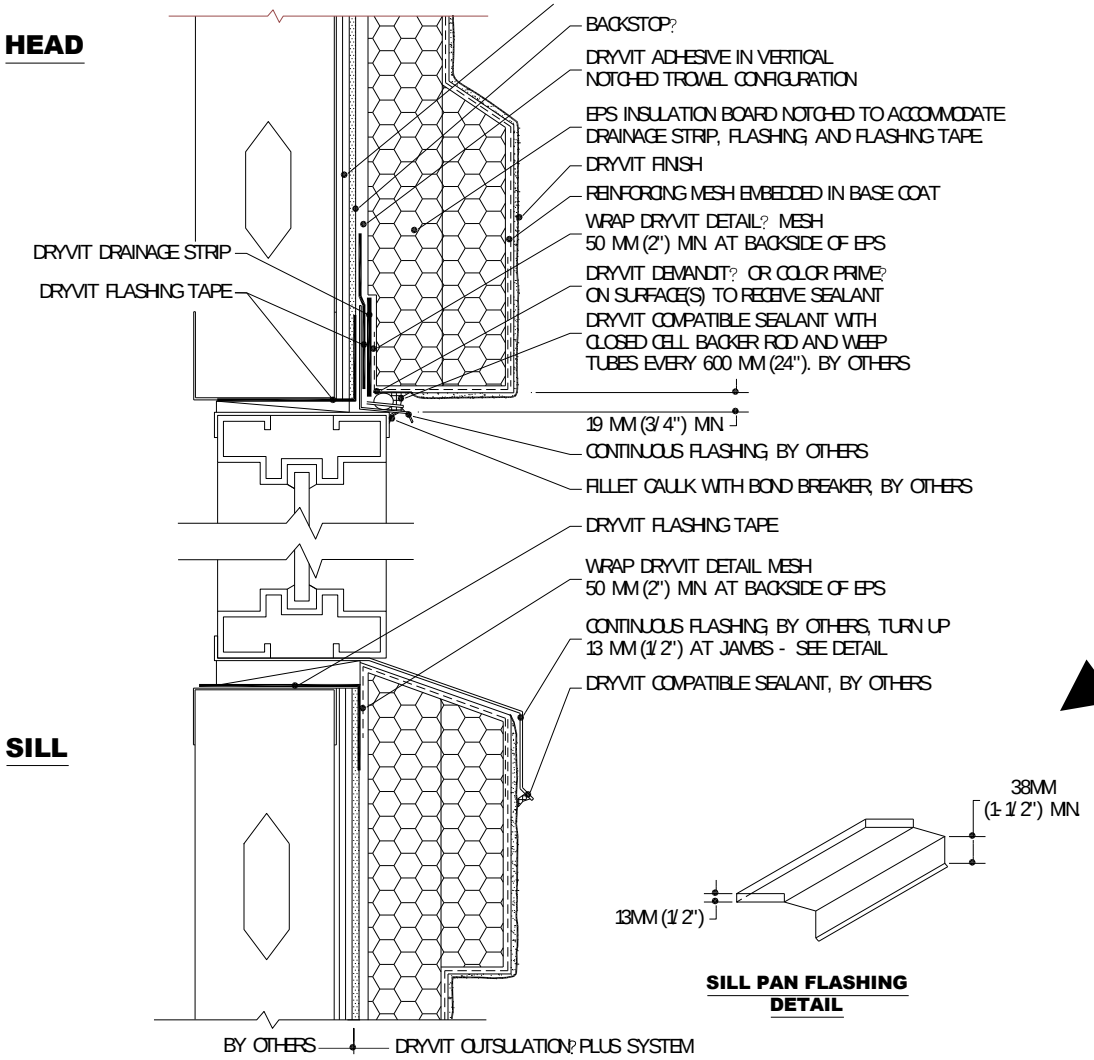
- 1997 UBC
- 1402.1 "Weather-resistive Barriers. All weather-exposed surfaces shall have a weather-resistive barrier to protect the interior wall covering. Such barrier shall be equal to that provided for in UBC Standard 14-1 for kraft waterproof building paper or asphalt-saturated rag felt.
- 2006 IBC
- 1404.2 Water-resistive barrier. "A minimum of one layer of No.15 asphalt felt, complying with ASTM D 226 for Type 1 felt or other approved materials, shall be attached to the studs or sheathing, with flashing as described in Section 1405.3, in such a manner as to provide a continuous water-resistive barrier behind the exterior wall veneer."

- 2006 IBC
- *1404.2 Water-resistive barrier Commentary*

- *Many exterior veneers provide weather resistance but may allow either penetration of water through joints or seams or the development of condensation to occur behind the veneer. To increase the weather resistance of the wall, a layer of asphalt felt or other approved material is required to be installed over the wall backing.*

- Asphalt Felt can be a vapor retarder!

All openings must have flashings



Sill pan flashings with rear and side dams

Flashings / Counter-flashings

- 1997 UBC
- 1402.2 “Flashing and Counterflashing. Exterior openings exposed to the weather shall be flashed in such a manner as to make them weatherproof.”
- *Opening “flashing” is not required to be metal.*

- All parapets shall be provided with coping of approved materials. All flashing, counterflashing and coping, when of metal, shall (be … 26 gage galvanized sheet metal gage) corrosion-resistant metal.

- 2006 CBC *See next slide*

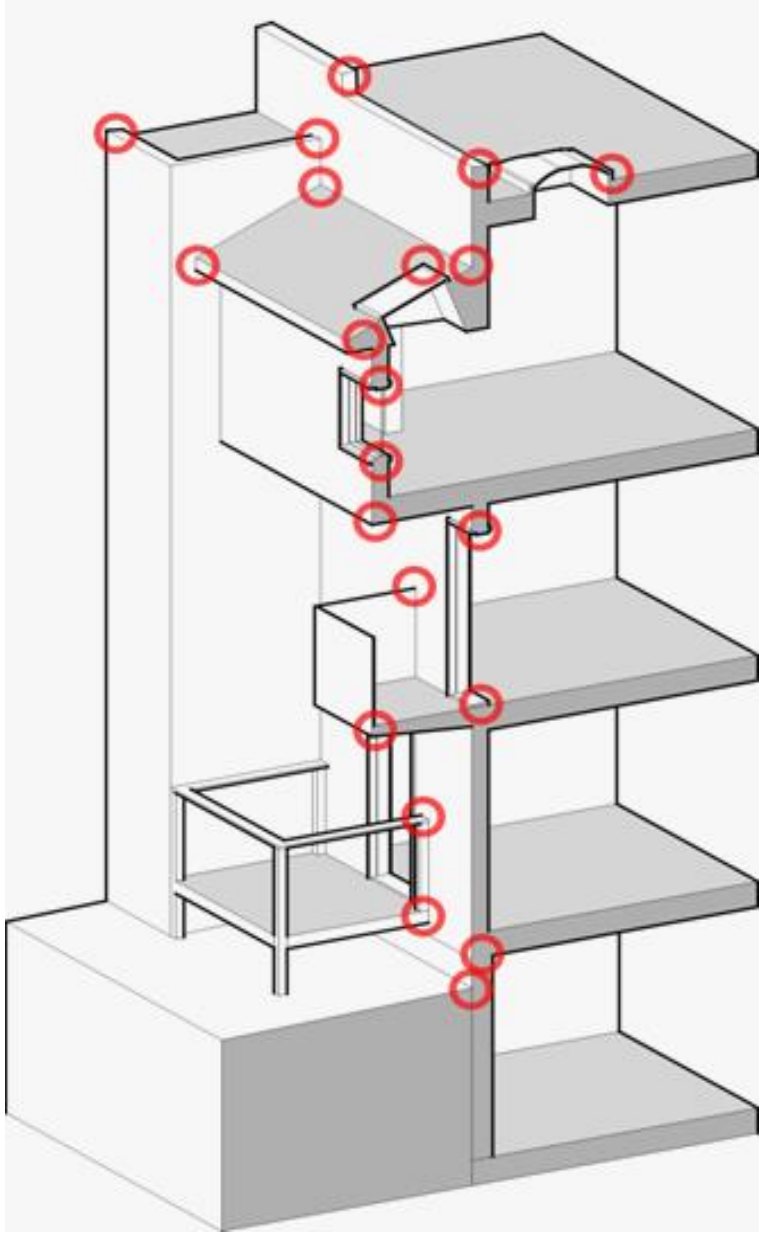
Flashings / Counterflashings (cont.)

- 2006 IBC
- *IBC calls for metal flashing at all material transitions. Saddle flashing at all building intersections is now mandatory*.

- Section 1405.3 "Flashing. Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior. Flashing shall be installed at the perimeters of exterior wall assemblies, penetrations and terminations of exterior wall assemblies, exterior wall intersections with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting trim."

Enclosure Design: Details

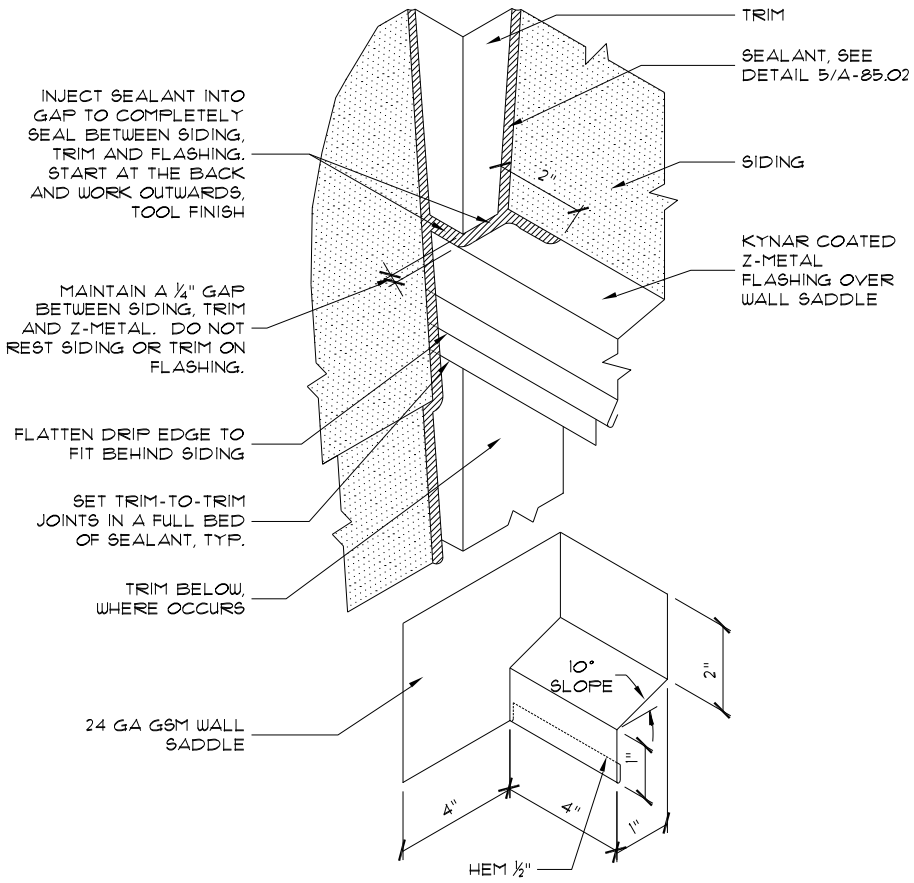
- Details demand the same approach as the enclosure.
- Scaled drawings required at ○
- Rain, Air, Heat *continuity*



Exterior wall flashing

- 1997 UBC
- 1402.2 “Exterior openings…shall be flashed…”
- 2006 IBC
- 1405.3 Flashing. Flashing shall be installed in such a manner so as to prevent moisture from entering the wall or to redirect it to the exterior. Flashing shall be installed at the perimeters of exterior door and window assemblies, penetrations and terminations of exterior wall assemblies, exterior wall intersections with roofs, chimneys, porches, decks, balconies and similar projections and at built-in gutters and similar locations where moisture could enter the wall. Flashing with projecting flanges shall be installed on both sides and the ends of copings, under sills and continuously above projecting trim.

Saddle flashing With Projecting Fin



Vapor Retarders in Exterior walls

- 1997 UBC
- No requirements for vapor retarder for exterior walls.

- 2006 IBC
- 1403.3 Vapor retarder. An approved vapor retarder shall be provided.
- Exceptions:
- 1. Where other approved means to avoid condensation and leakage of moisture are provided.
- 2. Plain and reinforced concrete or masonry exterior walls designed and constructed in accordance with Chapter 19 or 21, respectively.

Exterior wall flashing

- 1997 UBC
- 1402.2 “Exterior openings…shall be flashed…”
- 2006 IBC
- 1405.3.1 Exterior wall pockets. “In exterior walls of buildings or structures, wall pockets or crevices in which moisture can accumulate shall be avoided or protected with caps or drips, or other approved means shall be provided to prevent water damage.”

- *Caps need solid blocking to avoid denting when walked over and preferably ½ inch slope.*

Exterior wall flashing

Gerhy's MIT window popouts at the head had a lack of slope to the exterior. Water and ice could accumulate over the windows and damage the structure.
Ice fell on pedestrians.

"…wall pockets or crevices in which moisture can accumulate shall be avoided or protected with caps or drips…"

NEXTDESIGN

CSI: CONSTRUCTION

Buildings expert Joseph Lstiburek points out some of the key potential mistakes in the raising of MIT's Stata Center.

Water Damage

The black layer is a peel-and-stick waterproof membrane [1]. The blue layer is the stainless-steel outside cladding of the building [2]. The metal skin is applied directly over the waterproofing, whereas there should be both space and insulation between them. This causes condensation, which erodes the wall.

Fishmouthing

In the upper-left-hand corner, where a wall of windows meets another wall [3], the waterproof layer appears to be wrinkling. That's "fishmouthing" of the membranes, caused by inexpert application, which lets in moisture.

Window Leaks

The design's multiple windows [4] each provide an opportunity for failure in the wall-to-window connections, one source of the building's leaks. This image, though, doesn't conclusively show whether the connections were handled properly.

schedule). And now the school has turned to the courts to express its buyer's remorse. A lawsuit filed in October against both the construction firm and the architect alleges "design and construction failures," negligence, and breach of contract, which have cost the university $1.5 million in repairs already, with millions more likely to come.

The suit grabbed headlines because the architect's name is Frank Gehry, fueling a backlash against celebrity architects and their flashy designs. The go-to guy for this take is John Silber, the former president of Boston University, who has just published a book called *Architecture of the Absurd: How "Genius" Disfigured a Practical Art.* The Stata Center is on the cover.

This kerfuffle may have little to do with outward appearances, though. True, some of Gehry's other buildings have been tweaked after opening their doors, as when the steel-sided Disney Concert Hall in Los Angeles had to be sanded to remove a glare that could practically cook eggs on the sidewalk. And occupants have questioned elements of the Stata Center's design. ("I still would prefer straight to slanted walls, so as to put up bookshelves and a blackboard," says linguist Noam Chomsky, who has an office there.)

But what about the "construction" piece of the lawsuit? What if the Stata Center's woes are really about the growing gulf between computer-aided design and literal bricks and mortar? To find out, I decided to visit MIT with the Sherlock Holmes of construction.

"THIS WAS INCREDIBLY DUMB." I am standing at a Stata Center side entrance with Joseph Lstiburek as he points out a brick wall that meets a glass wall with a superficial connection, allowing moisture to seep across the porous brick from outside to inside. Lstiburek (pronounced *STEE-bu-rek*), an engineer with a PhD, is a frequent expert witness in construction lawsuits and an international authority on leaks who gets paid tens of thousands of dollars to cut holes in the sides of buildings and inform the owners how

50 FAST COMPANY February 2008

"An adhered membrane has no permeability. When it was exposed to freezing, condensation formed on the interior face."

The exterior wall envelope shall be designed **and constructed in such a manner as to prevent the accumulation of water within the wall assembly**

Exterior Windows and Doors

- 1997 UBC
- No weather resistance testing required
- 2006 IBC
- 1405.12 Exterior windows and doors. “Windows and doors installed in exterior walls shall conform to the testing and performance requirements of Section 1714.5.”

- *IBC Commentary*
- *“Windows and doors that are part of the exterior building envelope are to be tested for wind load resistance in accordance with the methods specified in Section 1714.5*”

Exterior Windows and Doors

- 1997 UBC
- No weather resistance testing required

- 2006 IBC
- *(Commentary: Lots of testing)*
- "1714.5.1 Exterior windows and doors. Exterior windows and sliding doors shall be tested and labeled as conforming to AAMA/WDMA/CSA101/ I.S.2/A440. The label shall state the name of the manufacturer, the approved labeling agency and the product designation as specified in AAMA/WDMA/ CSA101/I.S.2/A440. Exterior side hinged doors shall be tested and labeled as conforming to AAMA/ WDMA/CSA101/I.S.2/A440 or comply with Section 1714.5.2. Products tested and labeled as conforming to AAMA/WDMA/CSA101/I.S.2/A440 …."
- Or see next slide.

Exterior Windows and Doors (cont.)

Alternative test:

- 1714.5.2 Exterior windows and door assemblies not provided for in Section 1714.5.1. Exterior window and door assemblies shall be tested in accordance with ASTM E 330. Exterior window and door assemblies containing glass shall comply with Section 2403. The design pressure for testing shall be calculated in accordance with Chapter 16. Each assembly shall be tested for 10 seconds at a load equal to 1.5 times the design pressure.

Cement Plaster

- 1997 UBC
- Section 2506.4 Two layers of Grade D paper required over wood sheathing.
- 1402.1 “Exterior opening exposed to the weather shall be flashed in such a manner as to make them weatherproof.”

- 2006 IBC
- Section 2510.6 As one of the two layers, a plastic vapor-permeable barrier *(such as Tyvek or a drainage panel such as Stucco Flex or Delta Dry)* may be used. Furred rainscreen vent space may also count for one layer of underlayment.

Cement Plaster (cont.)

- <u>2006 IBC</u>
- Design weather exposed cement plaster per ASTM C926-98a:
  - ASTM C926
  - "A2.1.2 … Flashing shall be specified at openings, perimeters, and terminations… Flashing material shall be corrosion-resistant material."
  - **"A2.1.3 Sealing or caulking of V-grooves, exposed ends, and edges of plaster panels exterior work to prevent entry of water shall be provided."**

Moisture Management: Concept of Condensation/Diffusion

- Cement Plaster Wall
- Understanding Diffusion
- Vinyl Wall Paper
- Changes in Construction
- New Design and Construction Methods

SEMINAR OBJECTIVES

- Understanding moisture management in a stucco and EIFS wall assembly
- Thermal movement effects of metal studs in cement plaster walls
- Thermal movement effects of large foam shapes in EIFS assemblies

Moisture Movement and Drying Effects

- This Section of the seminar will cover:

- How *liquid water* moves through the exterior wall system behind lath and plaster
- How liquid water changes in to steam/vapor and dries through the wall system
- Condensation and moisture diffusion
- Permeance and permeability

Relevant Terminology:

- WATER PHASES
- RELATIVE HUMIDITY
- CONDENSATION
- WATER VAPOR TRASMISSION
- PERMEANCE/PERMEABILITY
- VAPOR PRESSURE
- DIFFUSION

WATER PHASES

- Water can exist in three phases
  - Ice
  - Liquid, between 32 degrees (freezing) and 212 degrees F (boiling)
  - Gas phase (steam) from boiling, or gas phase (water vapor) from evaporation, when the temperature is below boiling point
- When cooled, water vapor will lose energy and return to liquid, i.e., it will *condense*

RELATIVE HUMIDITY

- The amount of water in its gaseous phase that can be contained within a given volume of air is a function of the air's temperature:

  Warm air holds more moisture than cold air!!

- Relative humidity is expressed as a percentage: 100% humidity means that the air is saturated at that temperature

DIFFUSION/PERMEABILITY

- Diffusion is the transmission of water vapor through a material
- Some materials allow diffusion to occur more rapidly than others
- A material's ability to allow diffusion of water vapor is measured by "permeability" and "permeance"

PERMEANCE

- Permeance is based on given thickness of material.
  - Unit of measure = Perm
  - Is measured in perms per square meter
  - Rating under 0.5 = vapor barrier

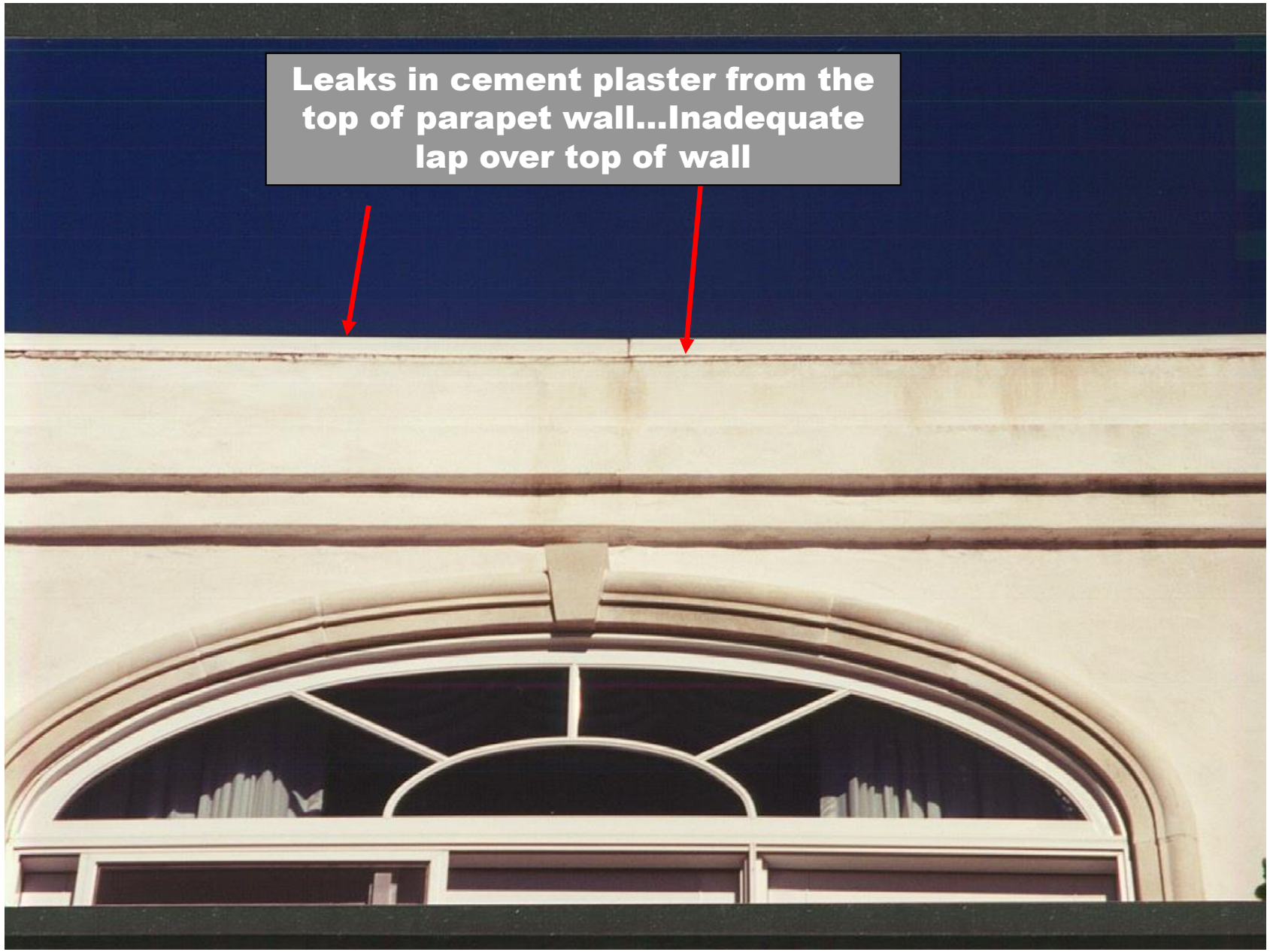
PERMEABILITY

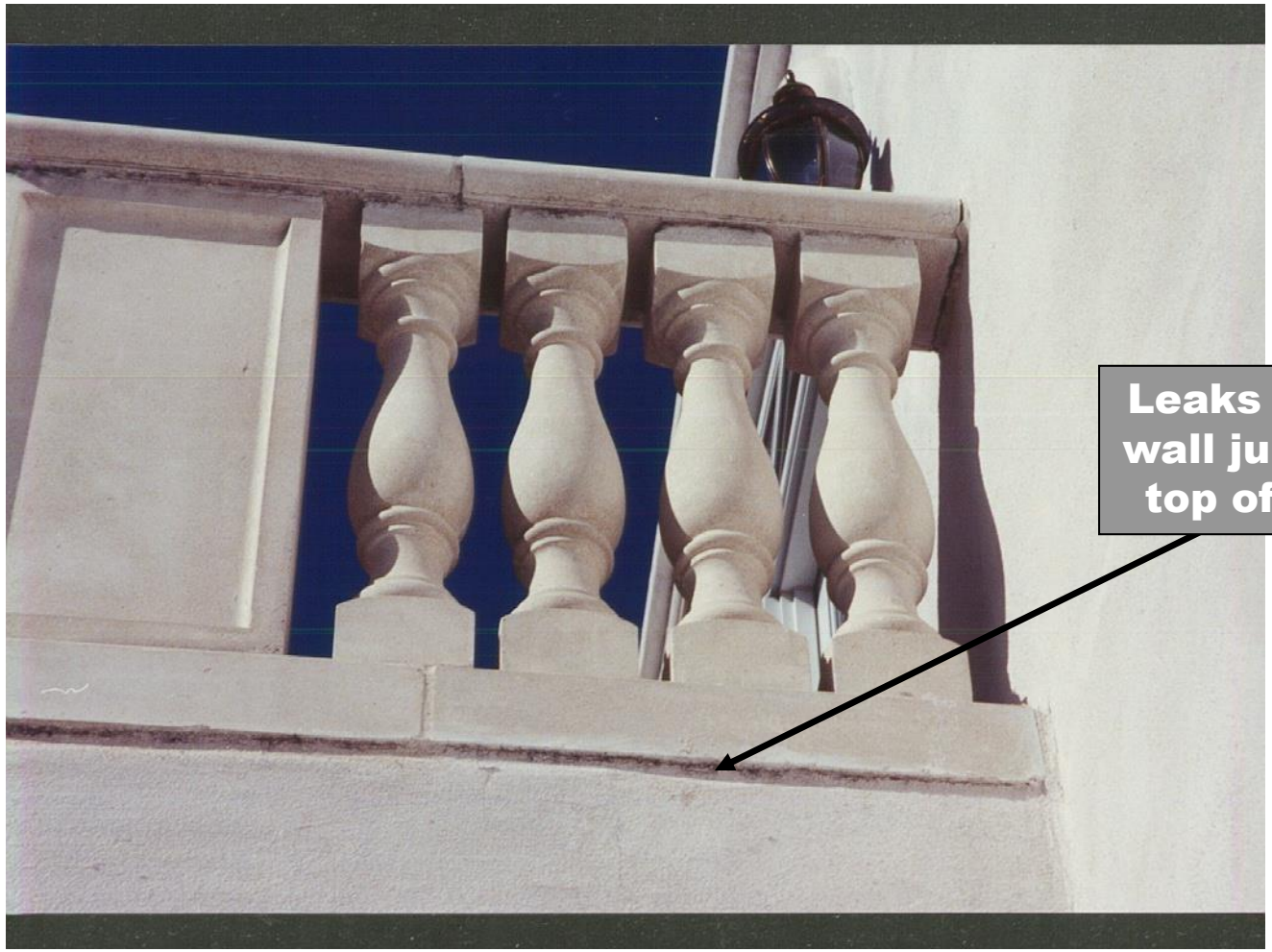
- Permeability is based on a given thickness range of material.
  - Unit of measure = Perm.inch
  - Example, Permeability of concrete = 3.2 perm.in
  - Permeance of 6” thick concrete slab = 3.2 perm.in/6” = .53 perm

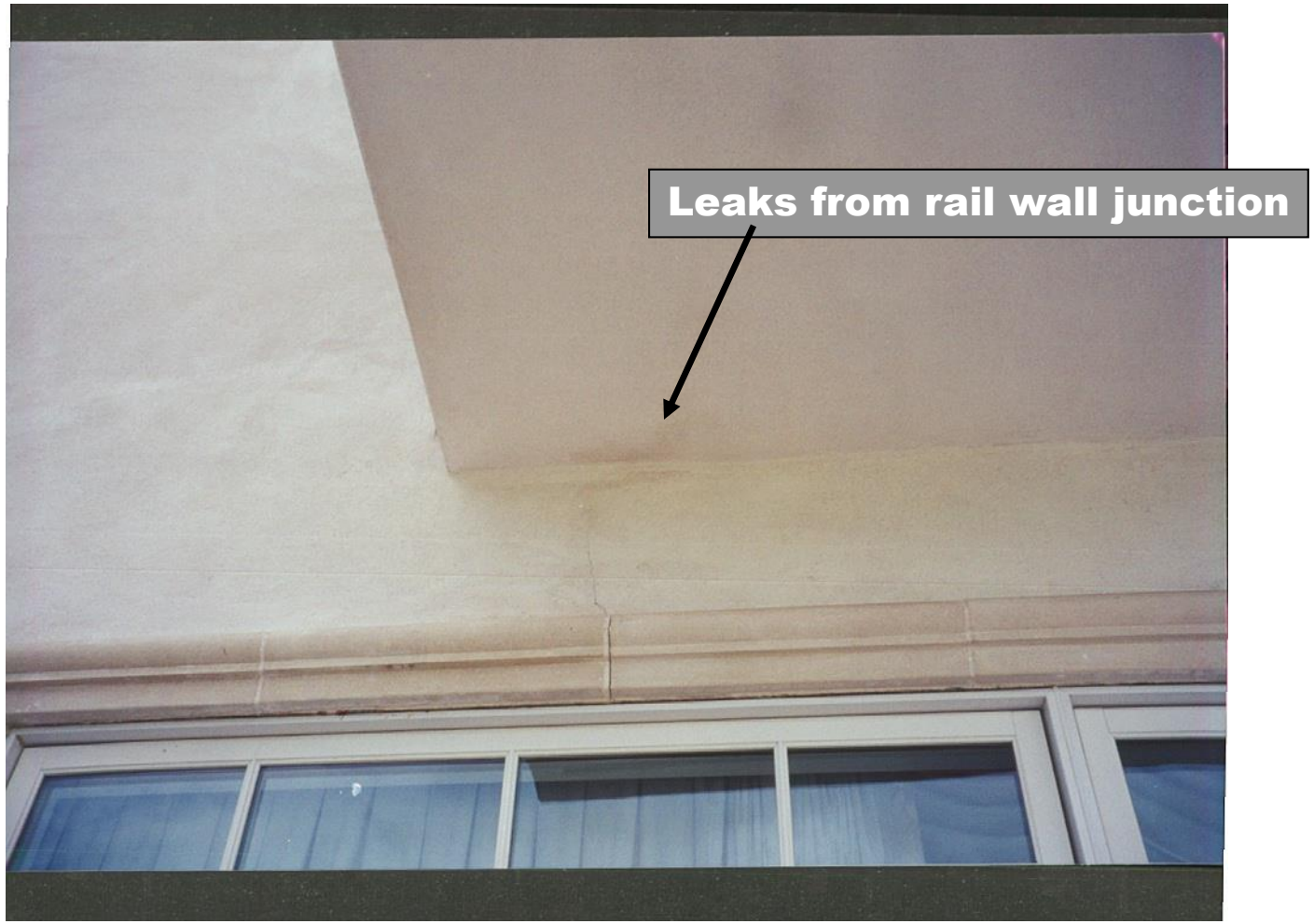
Figure 5

Typical Water Vapor Permeance and Permeability Values[1, 2]		
Material	**Permeance (perm)**	**Permeability (perm•in)**
Common roof membrane materials:		
Asphalt (hot applied, 2 lbs/100 ft²)	0.5	
Asphalt (hot applied, 3.5 lbs/100 ft²)	0.1	
Built-up membrane (hot applied)	0.0	
No. 15 asphalt felt	1.0	
No. 15 tarred felt	1.0	
Roll roofing (saturated and coated)	0.05	
Common insulation materials:		
Expanded polystyrene insulation		2.0 - 5.8
Extruded polystyrene insulation		1.2
Plastic and metal films and foils:		
Aluminum foil (1 mil)	0.0	
Kraft paper and asphalt laminated, reinforced	0.3	
Polyethylene sheet (4 mil)	0.08	
Polyethylene sheet (6 mil)	0.06	
Other common construction materials:		
Brick masonry (4 in. thick)	0.8	
Concrete (1:2:4 mix)		3.2
Concrete block (with cores, 8 in. thick)	2.4	
Gypsum wall board (plain, ³⁄₈ in. thick)	50	
Hardboard (standard, ¼ in. thick)	11	
Metal roof deck (not considering laps and joints)	0.0	
Plaster on metal lath	15	
Plaster on wood lath	11	
Plywood (Douglas fir, exterior glue, ¼ in. thick)	0.7	
Plywood (Douglas fir, interior glue, ¼ in. thick)	1.9	
Wood, sugar pine		0.4 - 5.4

Actual Project Examples





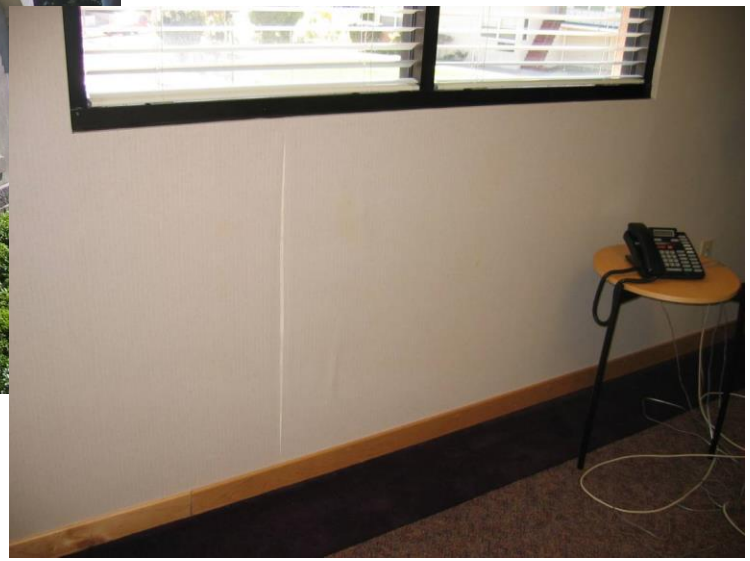


That innocent looking leak caused lot of damage…

Stucco leak from top of rail wall

Case Study # 2, Stucco Leak in wall. Study of slow diffusion

Few visible signs of distress



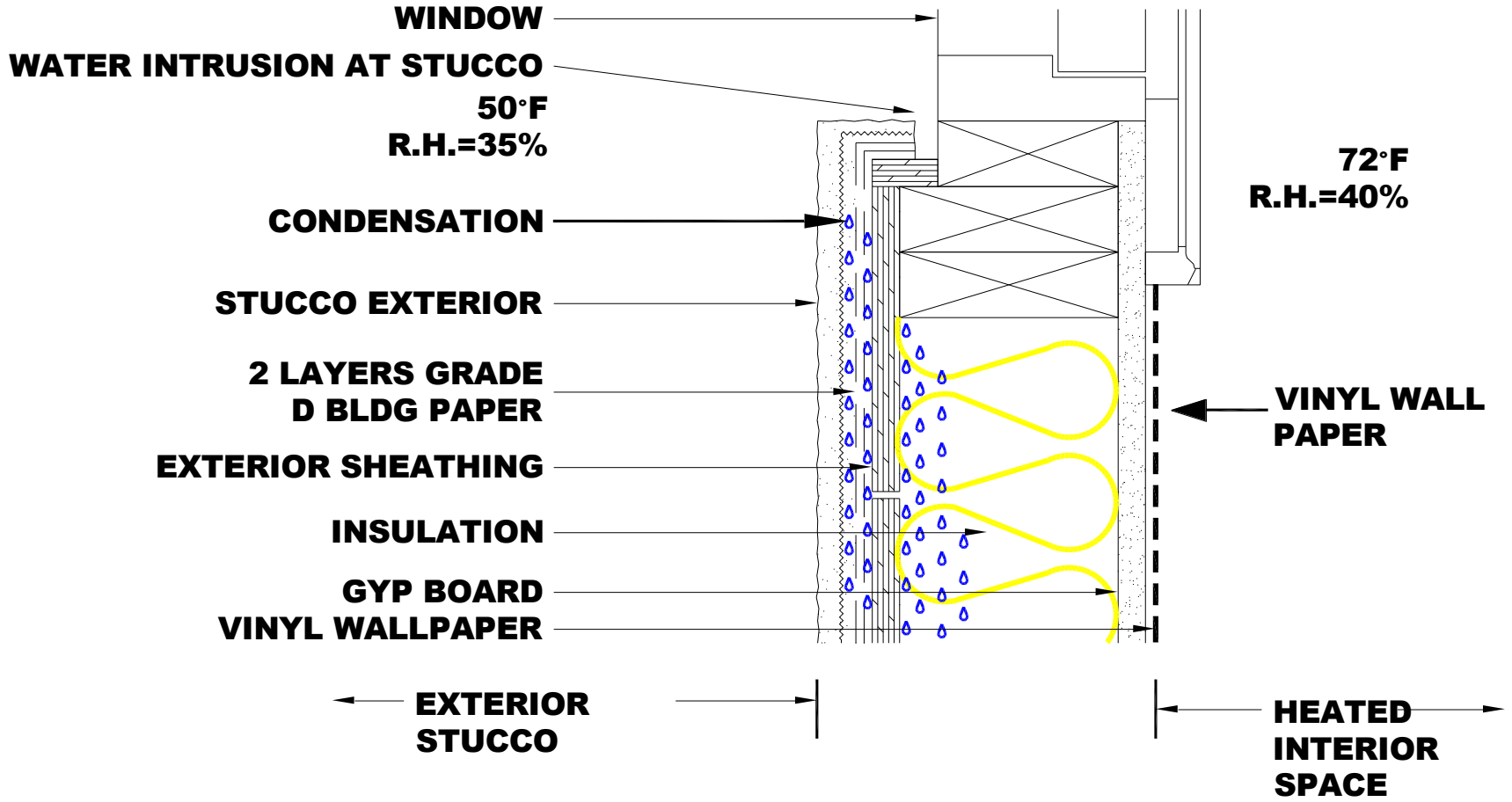
Relatively benign looking vinyl wall paper


Removal of a small area displayed evidence of some real problems

Slow diffusion due to vapor barrier on inside face of wall

Slow diffusion in wall can cause a lot of damage from leaks

Example 1: Window Leak: How long does it take for water to dry?



Water Leakage in Different Layers of a Wall assembly, How long before it dries?

During the rainy season, water collects in a wall due to a window or perimeter leak.

The affected area is 100 ft^2.

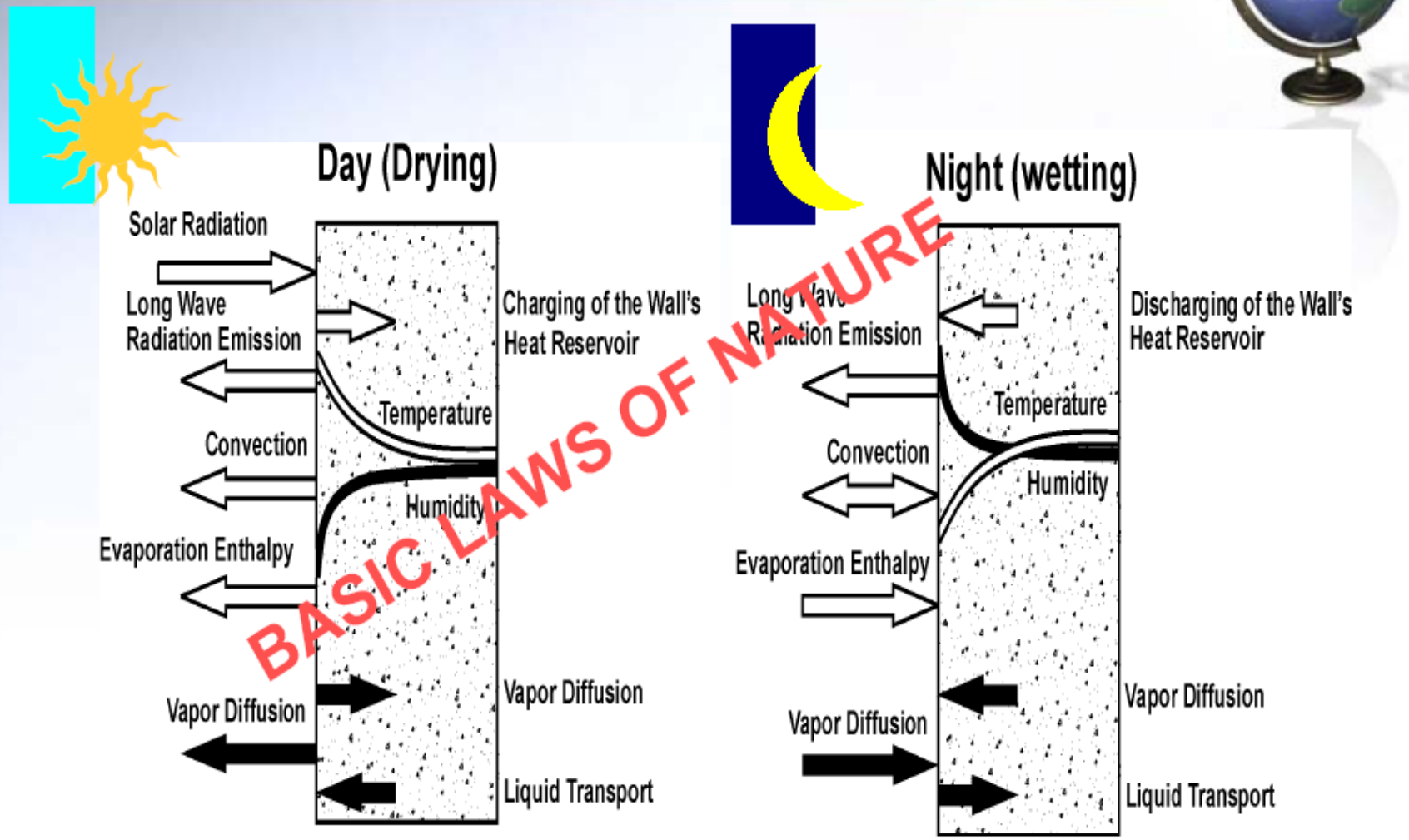
Outside temperature and relative humidity are 50F and 35% respectively.

The inside temperature and relative humidity are 72F and 40% respectively.

Under these conditions, moisture will flow from inside to outside.

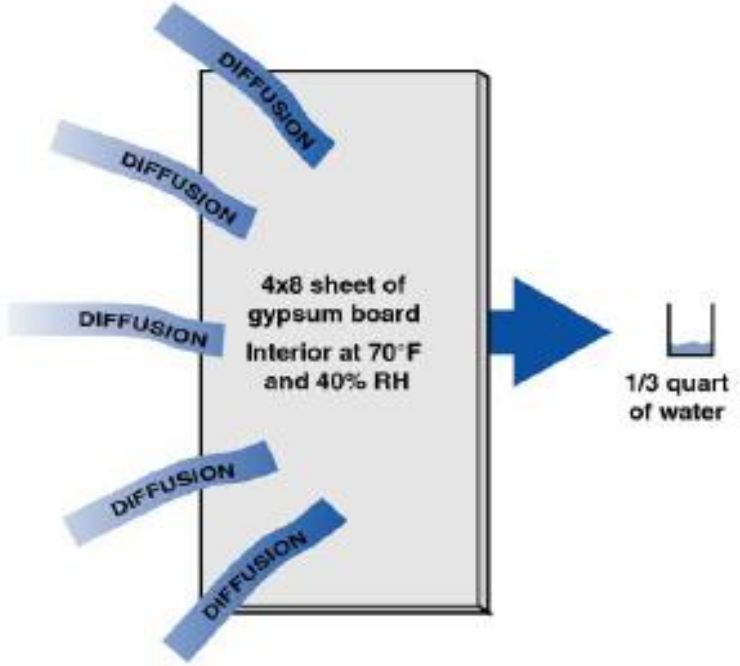
How much time will it take for the water to leave the assembly in various locations? Each location has 1 gallon of water intrusion.

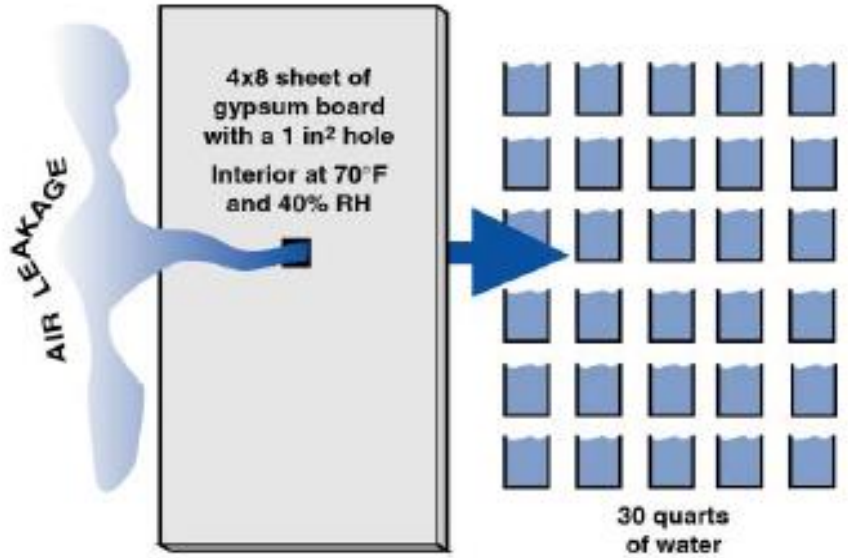
2. Hygrothermal Transport



CONVECTION

Wetting or Drying?





Example 2: Moisture trapped in different layers in the wall

- *How long does it take for 0.1 Gallon of water to dry (Due to diffusion) if trapped between paper & stucco?*

Determine the time required for diffusion at each location. Rearrange the Vapor Transmission Equation to isolate the time variable T:

$$VT = A \times T \times \Delta P \times \text{permeance}$$

$$T = VT / (A \times \Delta P \times \text{permeance})$$

T = 5,809 gr/(100ft2 x 0.0066 in.Hg x 15 perm)

= 587 hours

= 24 days

Example 3

Similarly, How long does it take for 0.1 Gallon of water to dry if trapped between OSB and paper?

T = 5,809 gr/(100ft2 x 0.0438 in.Hg x 2.143 perm)

= 619 hours

= 26 days

Example 3

Example 3: How long does it take for 1 Gallon of water to dry if trapped between Insulation and OSB?

T = 58094 gr/(100ft2 x 0.0907 in.Hg x 1.034 perm)
= 6190 hours
= 264 days

The rate of diffusion did not change from location 2. This value didn't change much; the local pressure increased, however the perm rating at this point decreased. However, I increased the amount of water to 1 gallon to allow for insulation's ability to absorb water.

Oak Ridge National Laboratory Research Study

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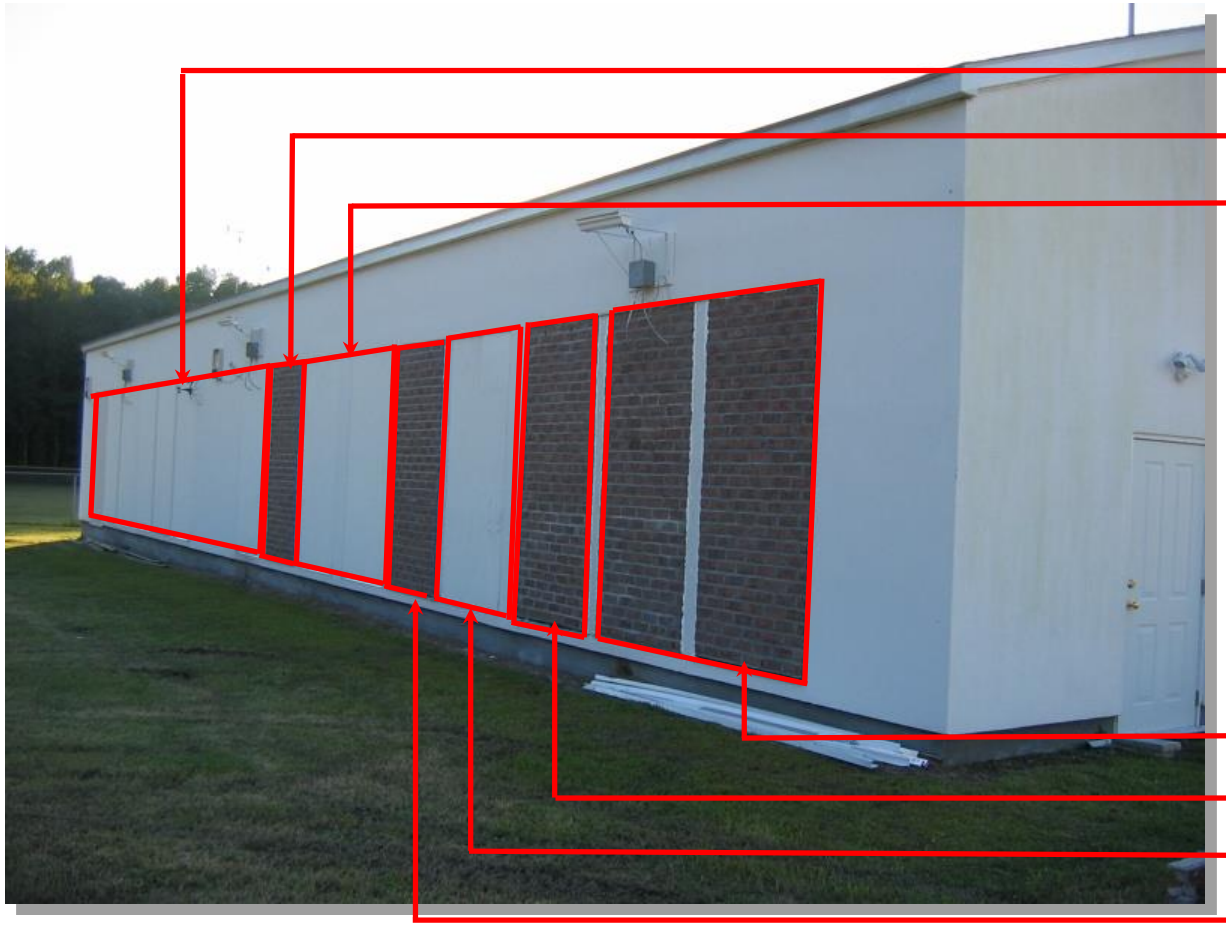
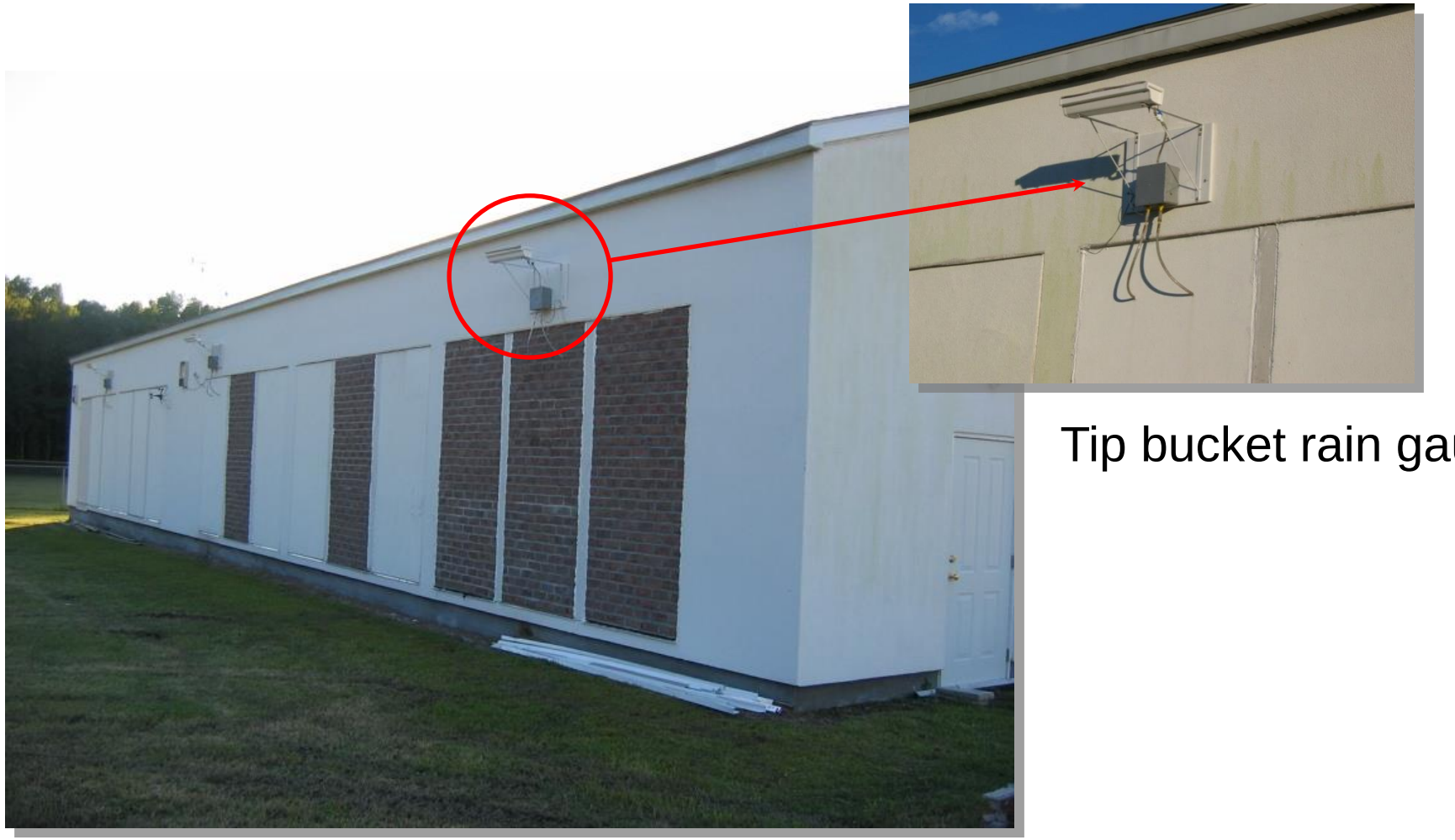
ORNL Study Building

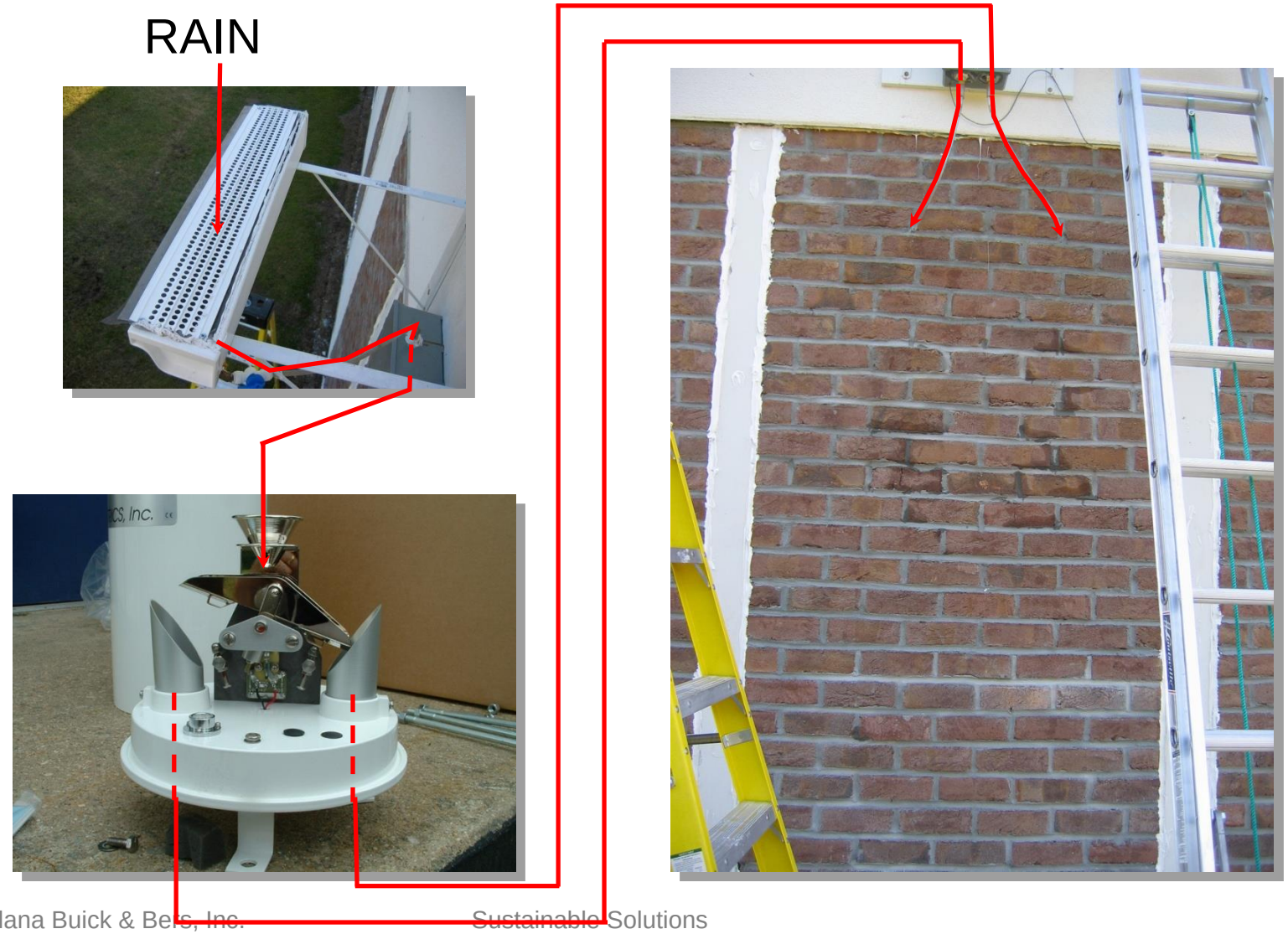


What's this ?

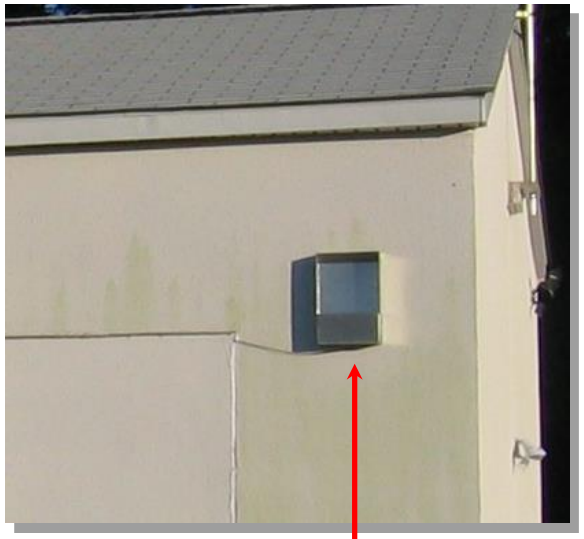


Tip bucket rain gauge

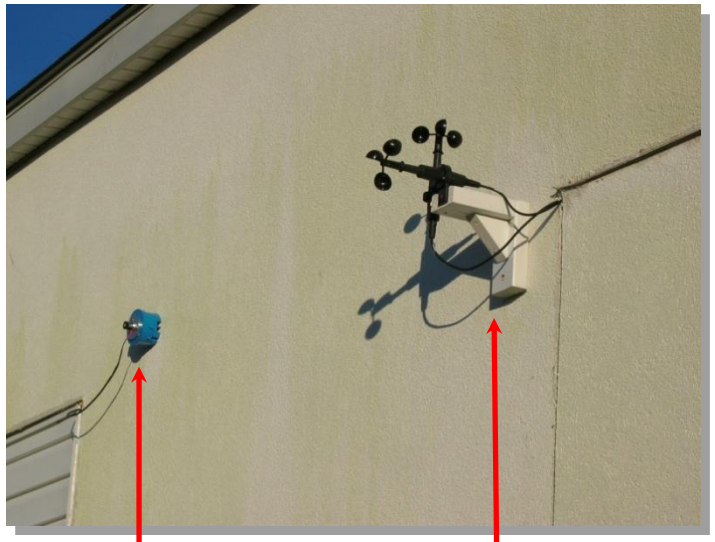
Tip Bucket Rain Gauge



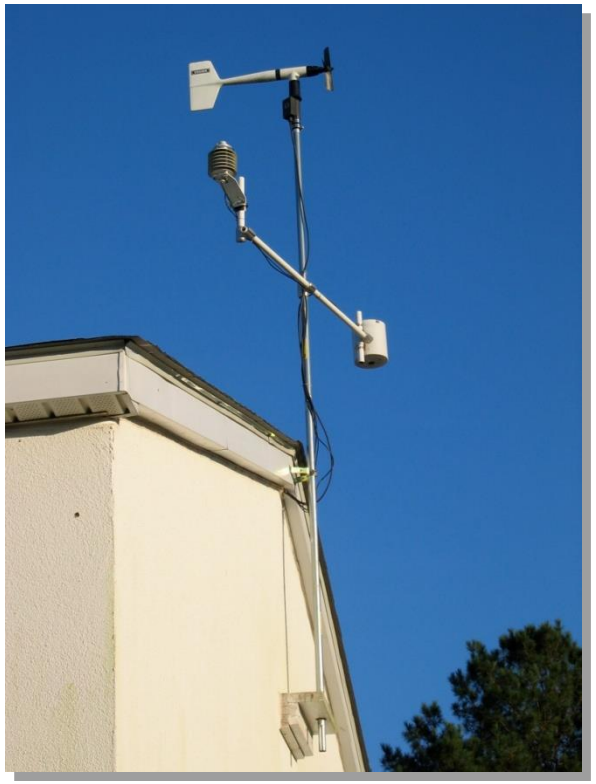
What else ?



Rain

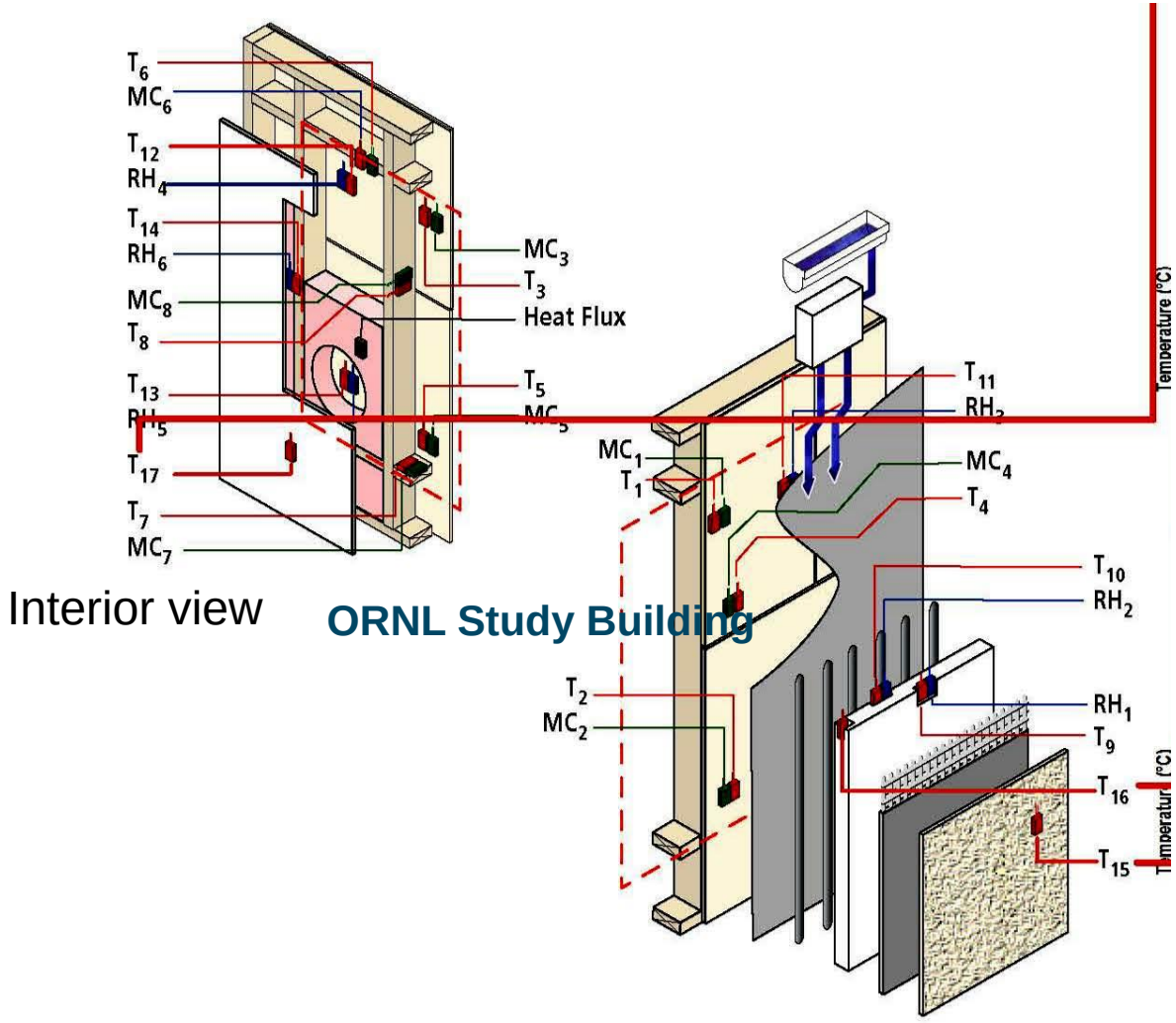


Solar Wind



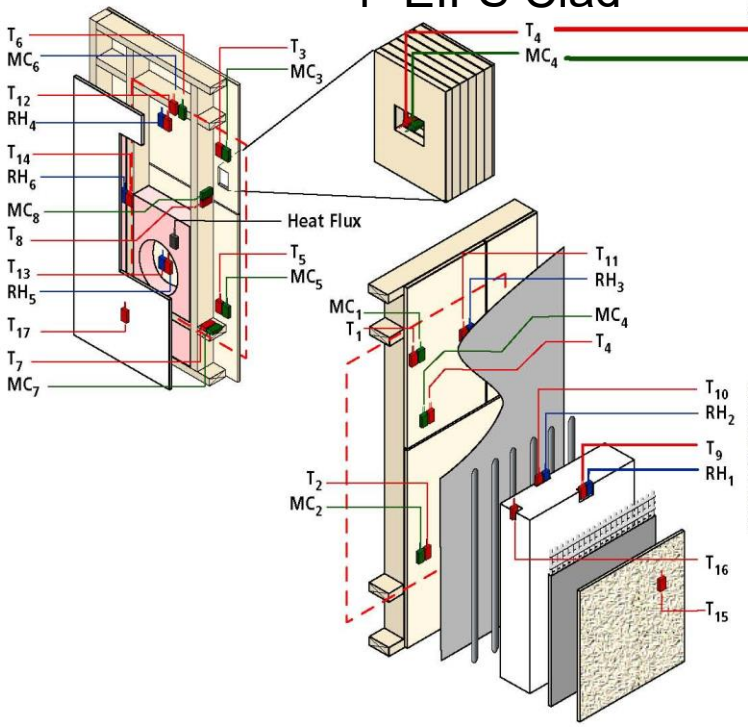
Weather station

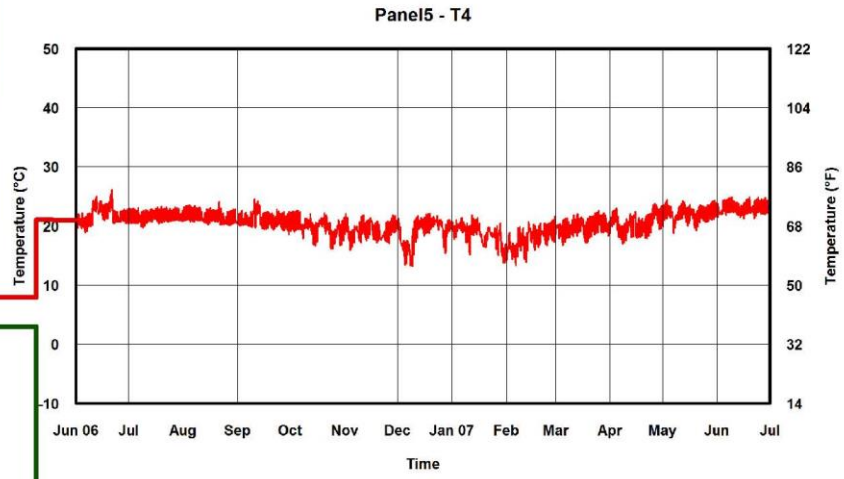
Panel Sensor Arrangement

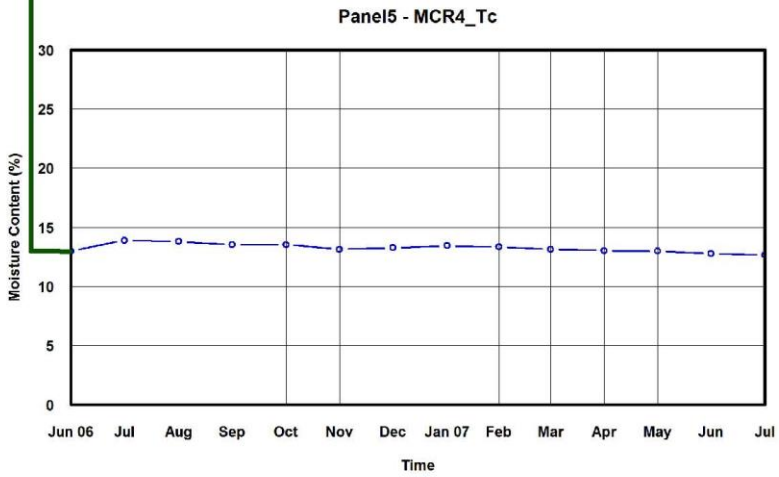


Panel 5

4” EIFS Clad

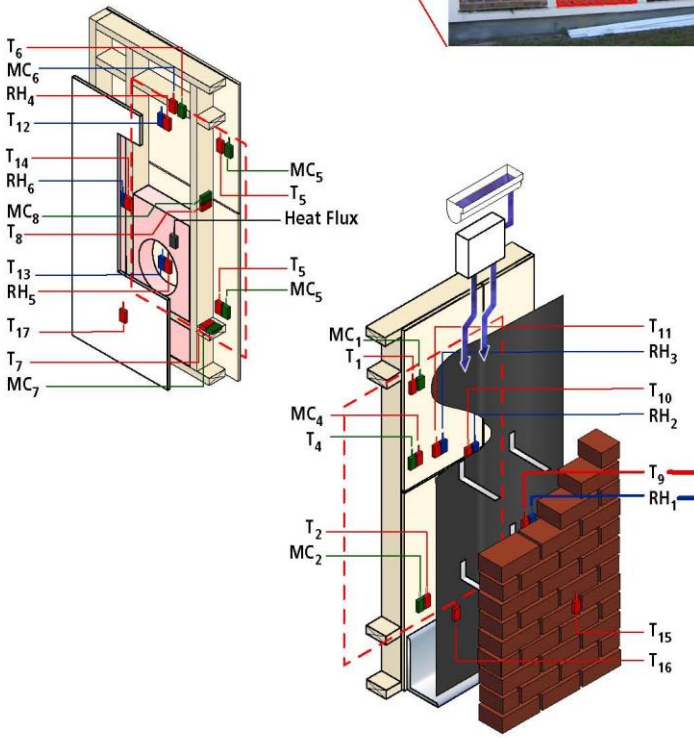


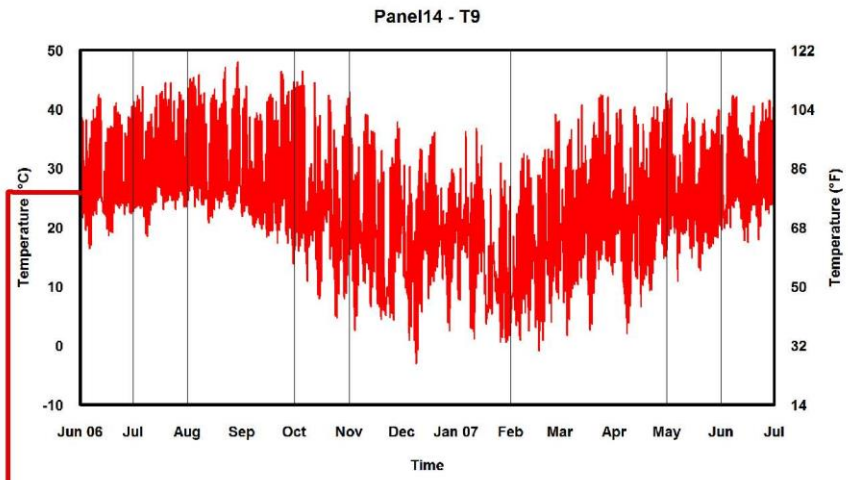


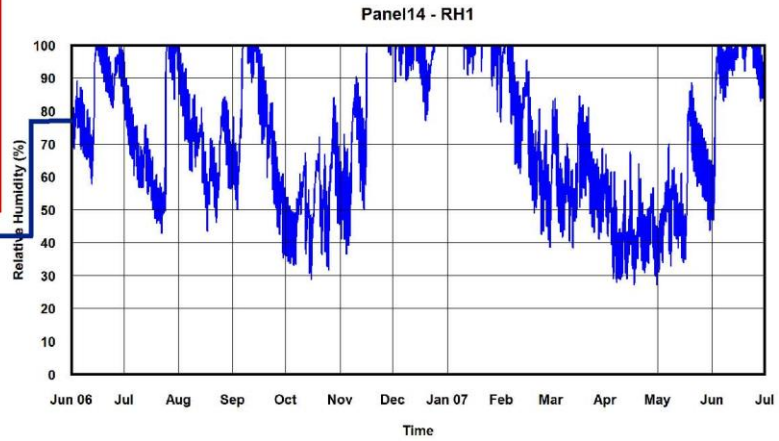


Panel 14

Brick Clad

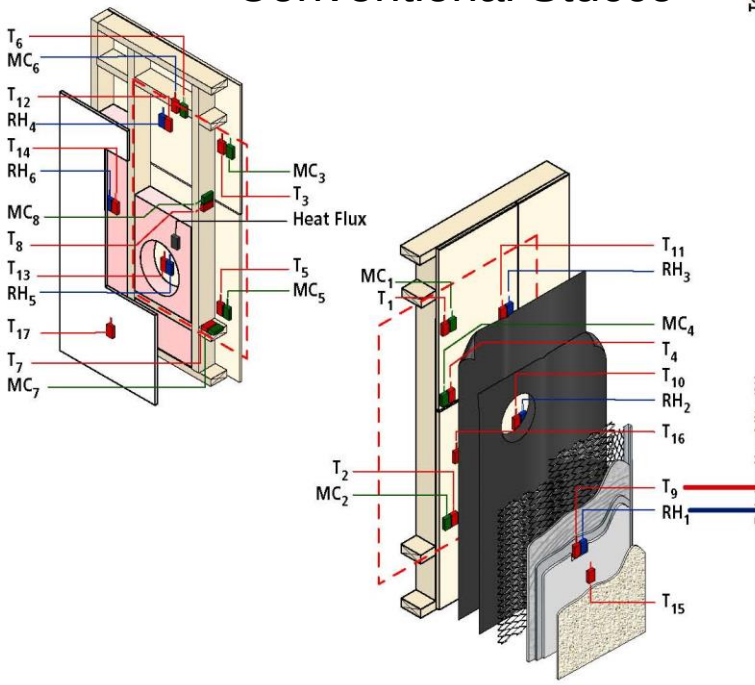


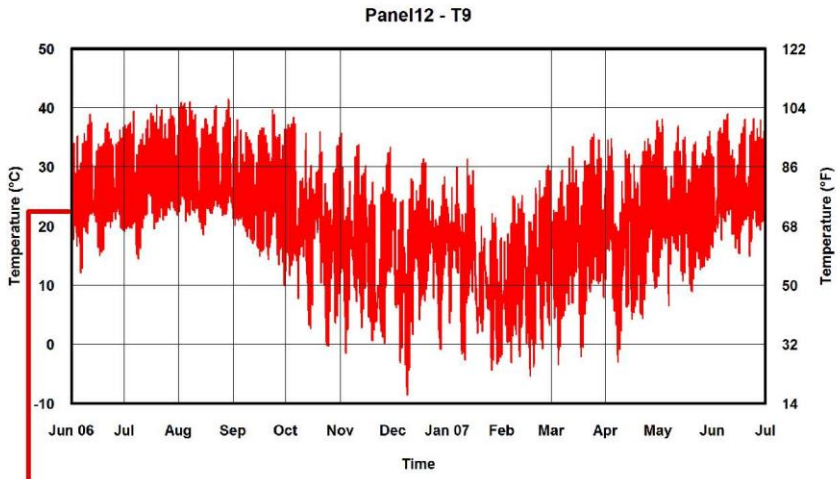


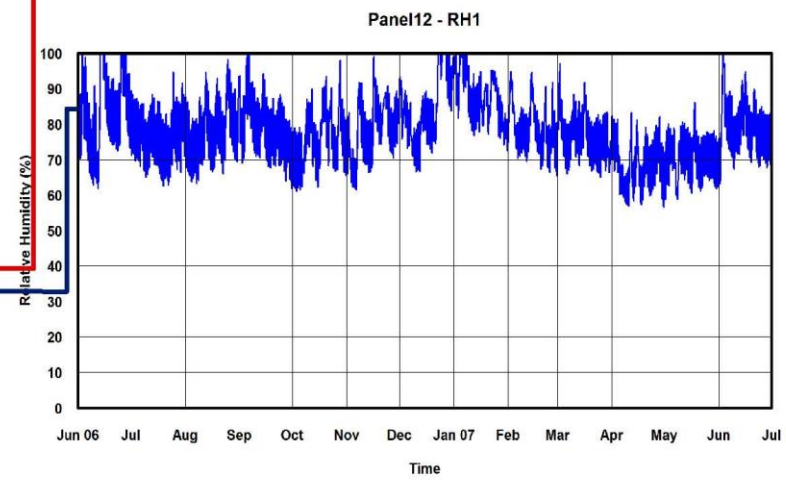


Panel 12

Conventional Stucco



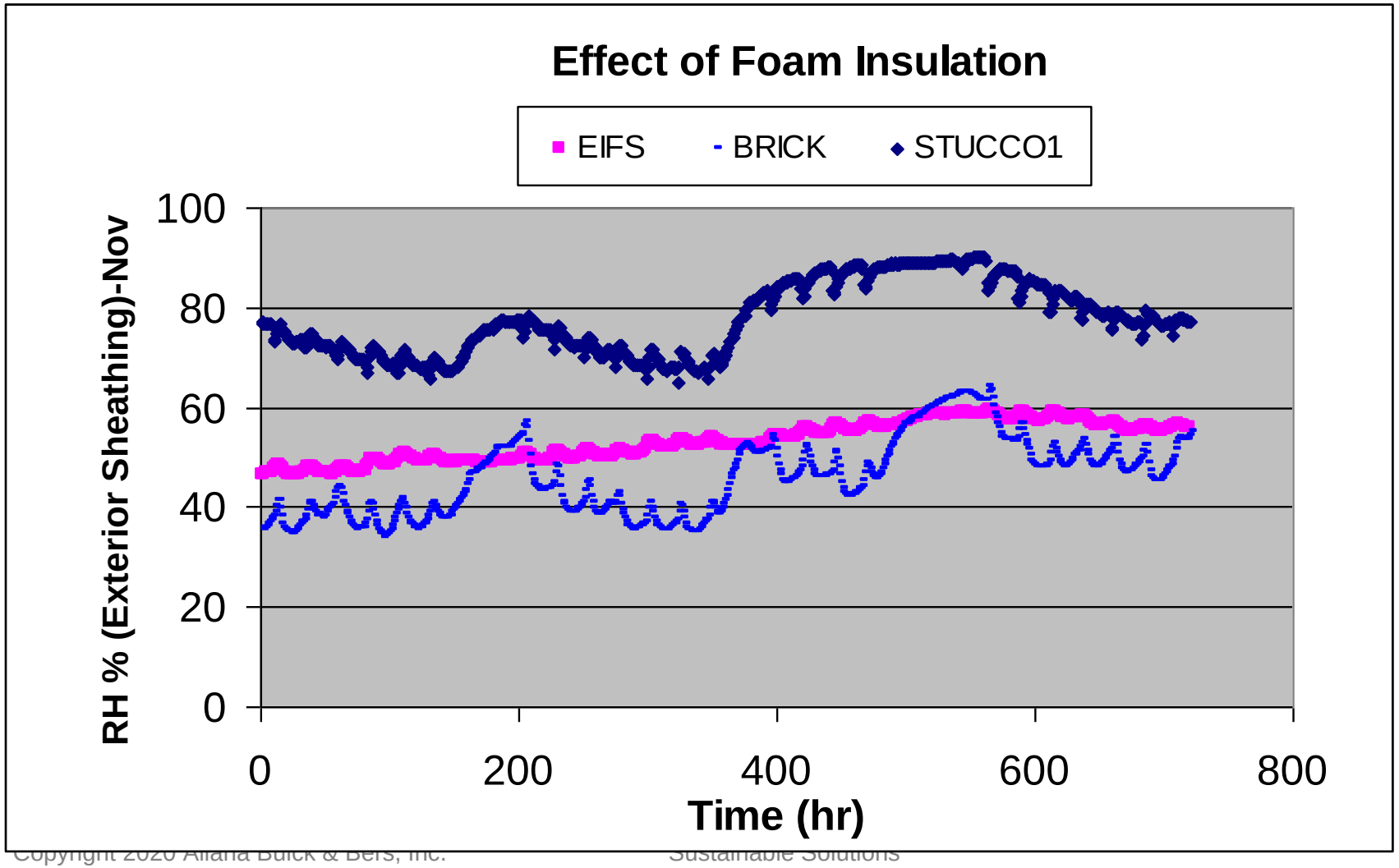




Compare EIFS vs Brick vs Stucco

YEAR 2

Brick #14 South Wall		NA	Air Cavity 1”	60 Min	OSB	2 x 4@16”	R-11 Unfaced	None

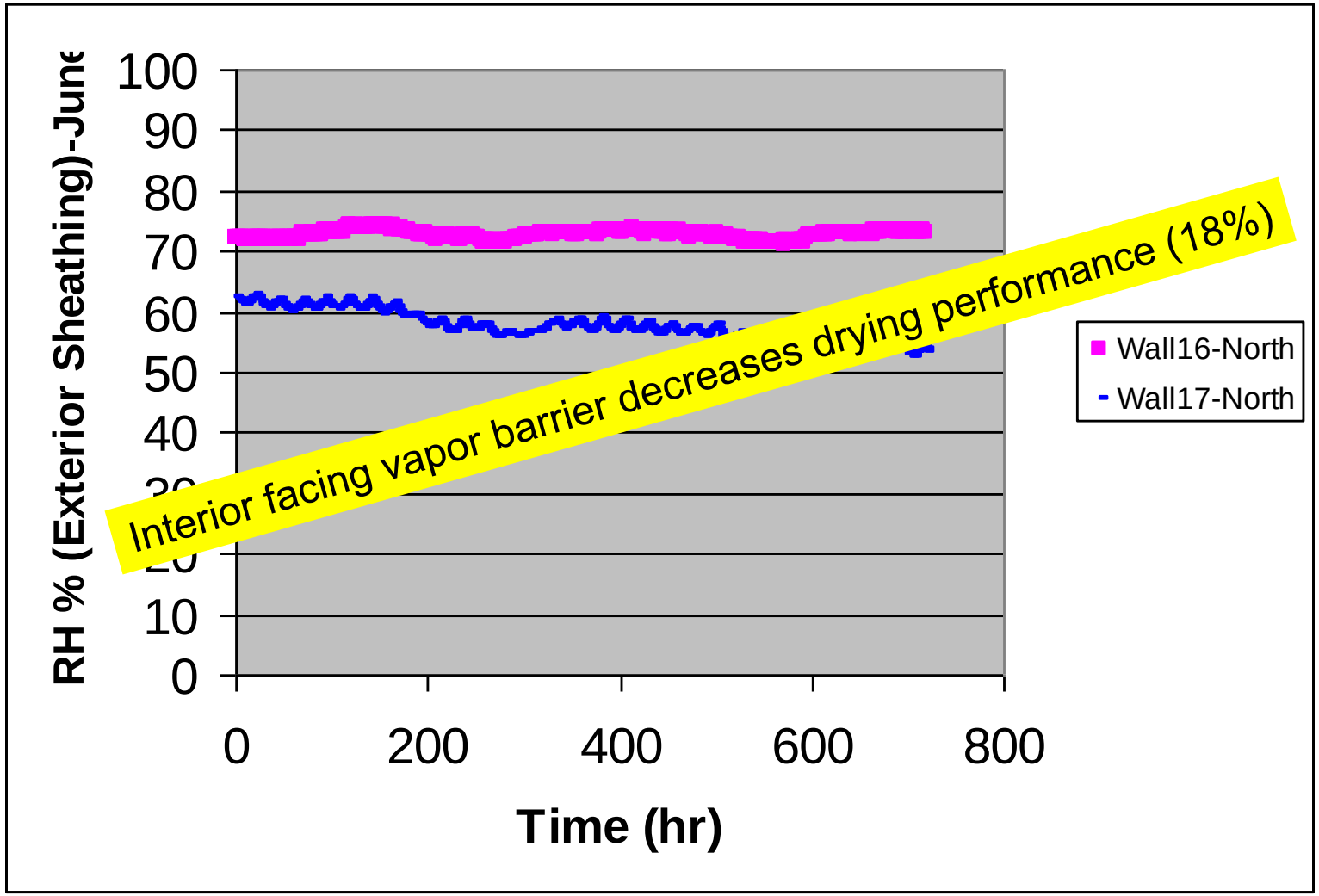


Nov

Compare North Poly (16) vs North No-Poly (17)

YEAR 2

EIFS #16 North Wall Vented	1 ½”	Notched Trowel	Vertical Ribbons	Liquid	Plywood	2 x 4@16”	R-11 Unfaced	6-mil poly



June

WALL MOISTURE DIFFUSION LESSONS

- Old stucco/siding system with just Grade “D” building paper and no consideration for managing excess water does not work.
- Acceptable tolerance for incidental water intrusion needs to be greatly reduced.
- Design should consider building cement plaster more as a “barrier” system.
- Provide for “rain screen” air movement and drying.

Understanding Impact of Wood Framing On Stucco

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WOOD EXPANDS WITH MOISTURE

- 4% moisture change in wood framing is enough to crack stucco
- Plywood sheets require 1/16” to 1/8” gap between adjoining sheets to allow for expansion
- OSB requires 1/8” to ¼” gap between sheets
- Lack of gap will increase cracking in stucco
- Wood framing less likely to cause expansion cracking due to thermal movement

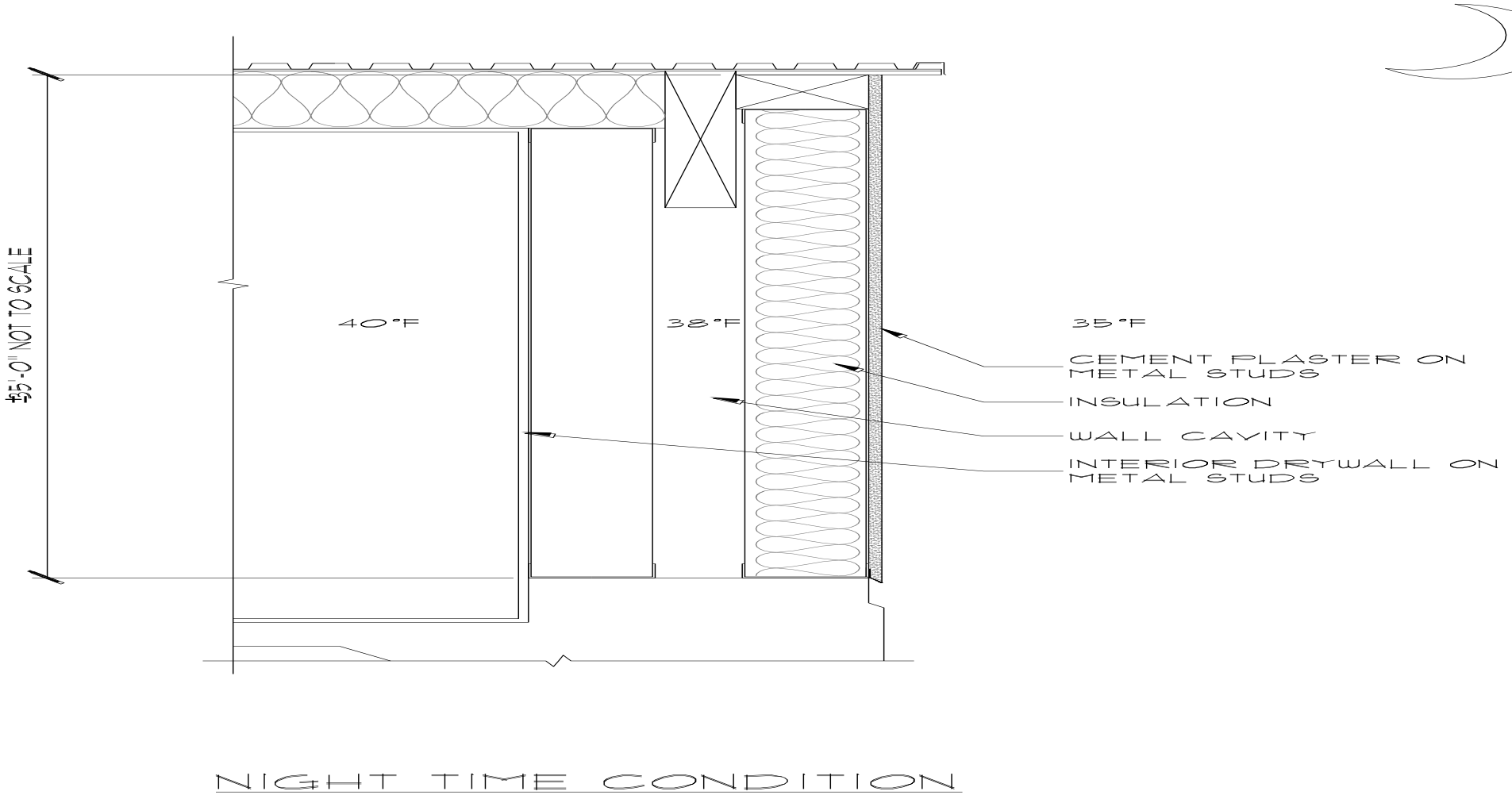
OSB is 600% more susceptible to rot, due to leaks and condensation as compared to plywood

Understanding Impact of Steel Frame On Stucco

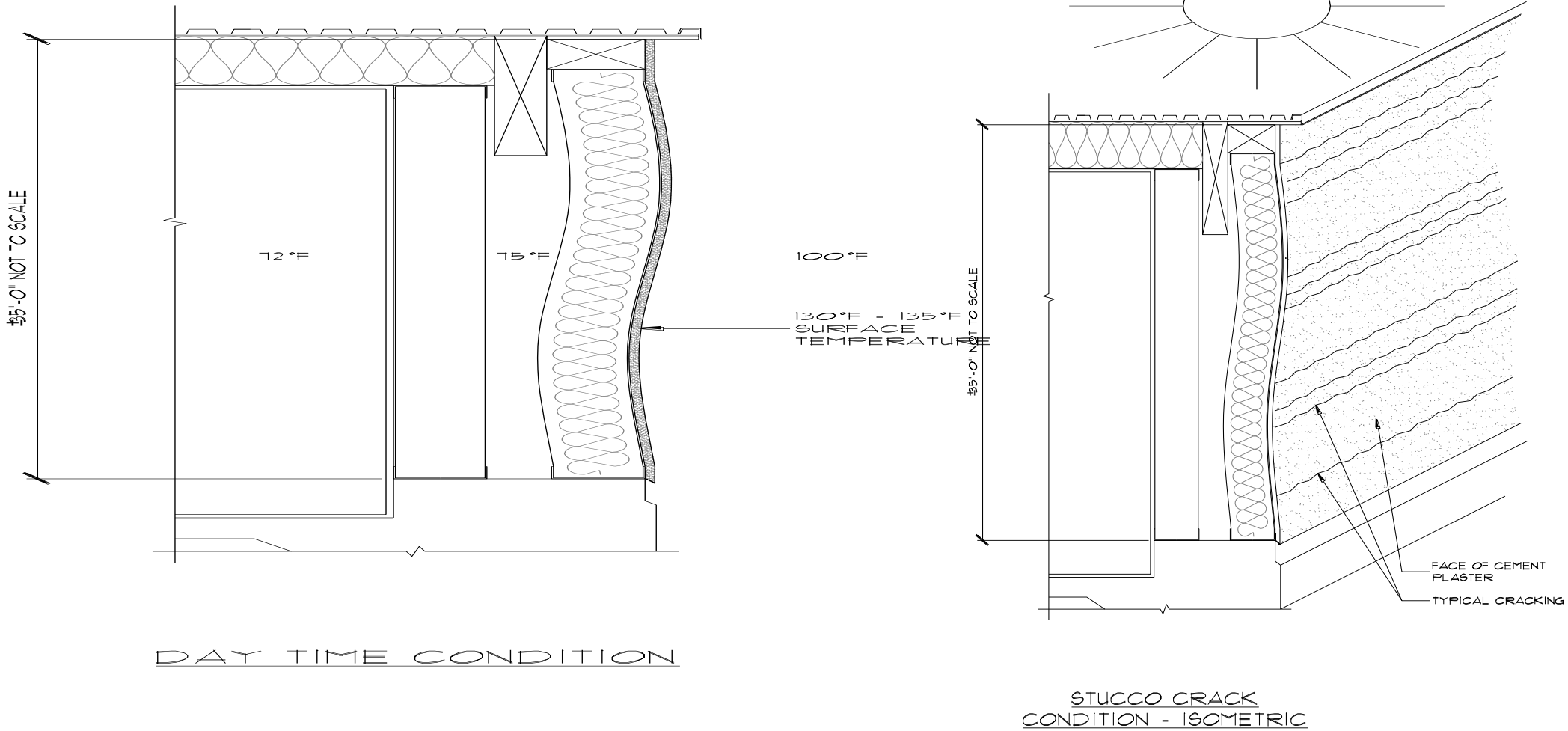
Stucco Cracks in Metal Stud Building

Stucco Cracks – Mostly Horizontal

Condition at Night



Condition During the Day



DAY TIME CONDITION

STUCCO CRACK
CONDITION - ISOMETRIC

Slip Tracks Reduce Thermal Cracks

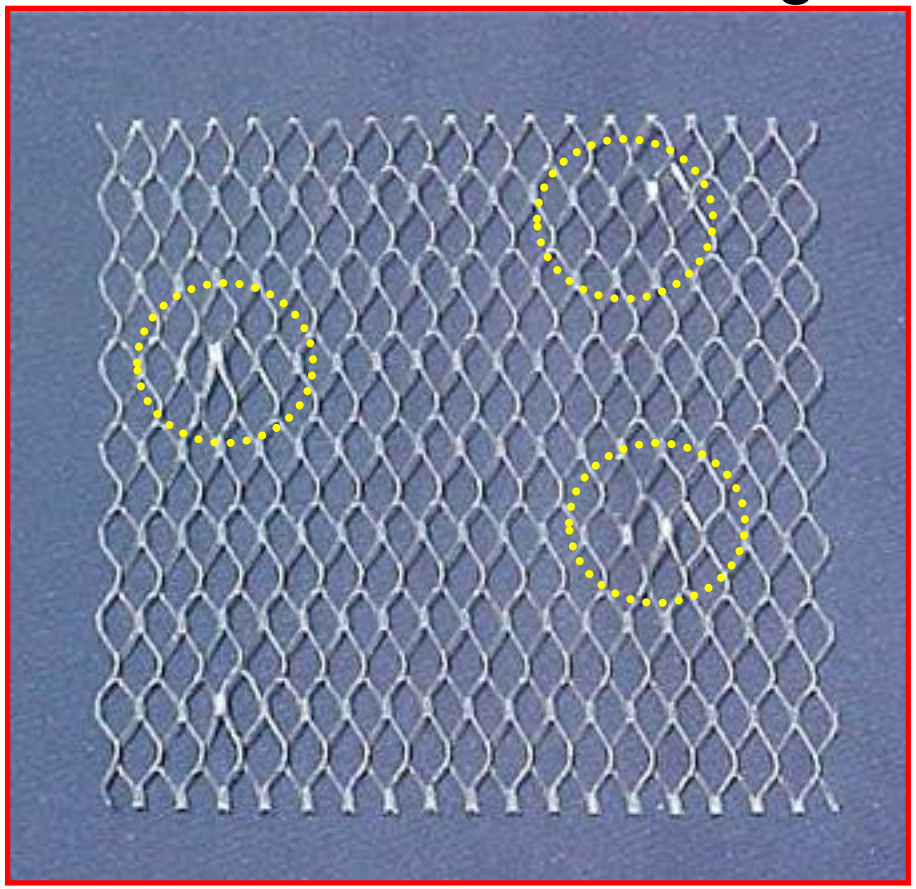
Lath Installation

- BEFORE YOU LATH…

1. Confirm that the waterproofing is 100% installed
2. Confirm that all sheet metal flashings are installed
3. Confirm that air barriers and backing sealants are in
4. Confirm that all stucco accessories are installed

Self Furring Lath

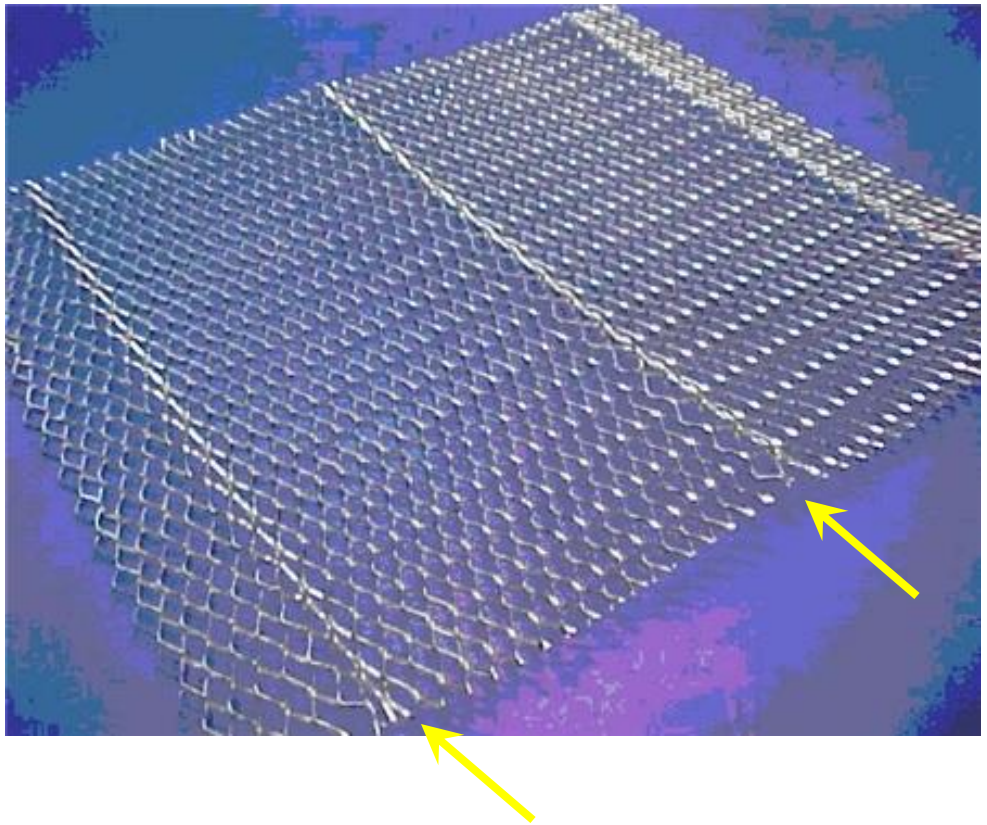
- Expanded Metal Lath: Self Furring Dimpled



- *Self furring dimples are typically spaced 6-inches O.C.*
- *Fasteners must be placed at the dimples in order for the lath to furr out*

Major Types of Lath

- Expanded Metal Lath: Self Furring V Grove



Self furring ribs are typically spaced 6, 9 or 12-inches O.C.

Lath Installation

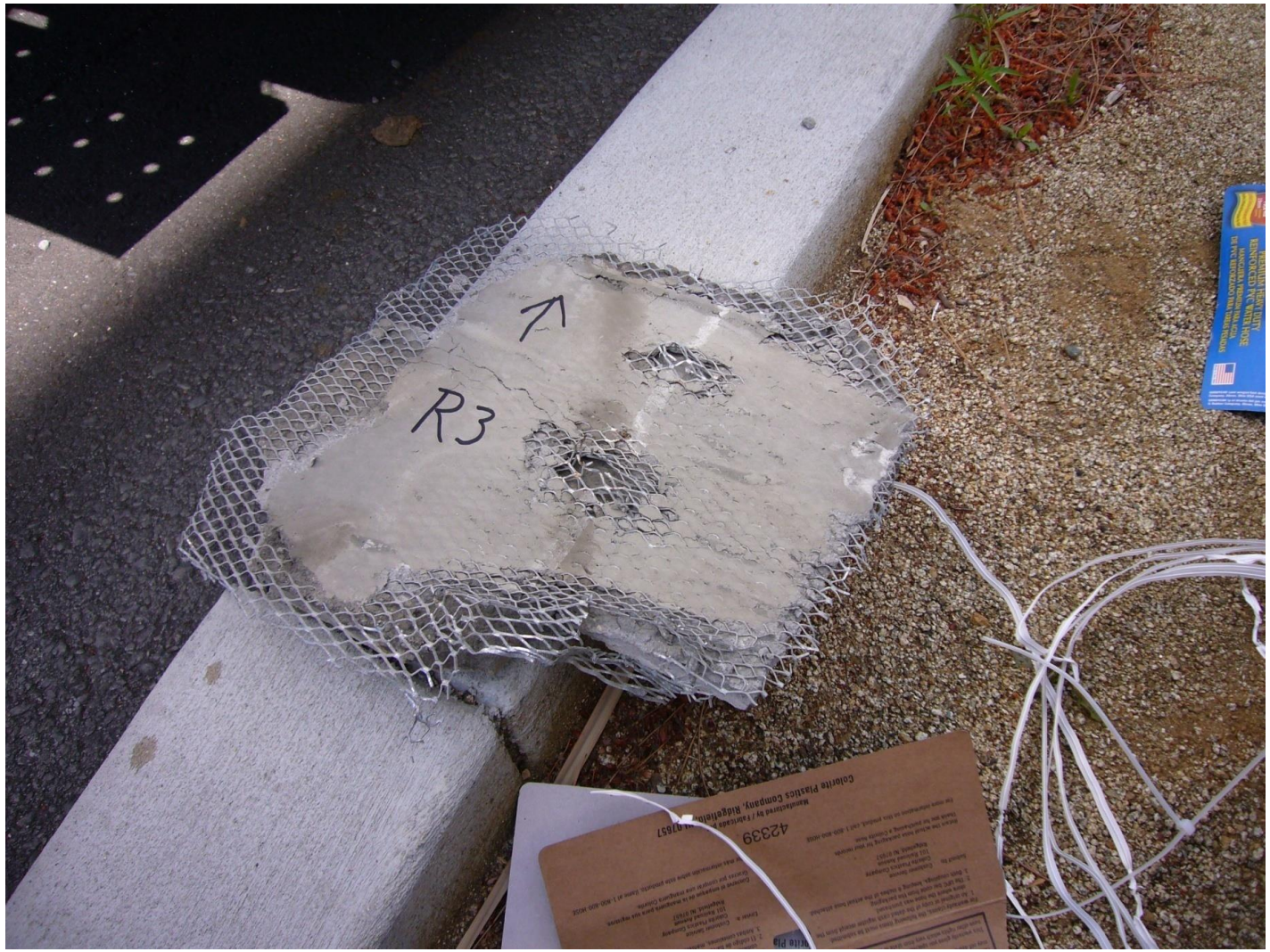
- Field Lath

1. Fasten 6 inches on center
2. Hit furring dimples or strips
3. If furring dimples or strips don’t align…use furring fasteners
4. Inspect for ¼” gap between waterproofing and lath

Self Furring Lath Not Secured at Dimples

Poor Furring due to Improper Fastening

Poor Lath Embedment Leads to Cracks

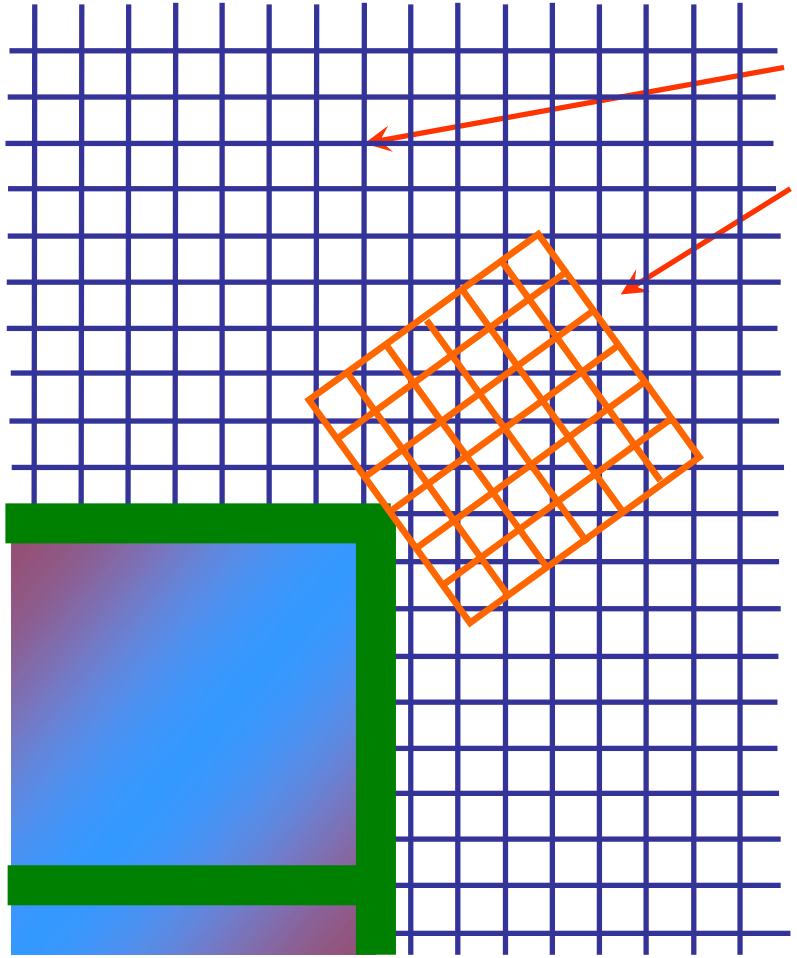


The *"Perfect Storm"*

- Energy efficiency = sealed buildings, more air tight, breathe less, create more places for water vapor and moisture to condense, causing damage
- Today's new growth timber and composites like OSB are far less water resistant
- Balloon Framed Steel Frame Construction
- Contractors are not keeping up with changes in "air tight" and "moisture sensitive" construction
- Lack of lath furring and moisture cure result in cracks and moisture intrusion.

Lath Installation

- Lath @ Punched Corners



Inside corner cracks can be eliminated by using this additional off axis reinforcement.

Building Paper & Flexible Flashing Application

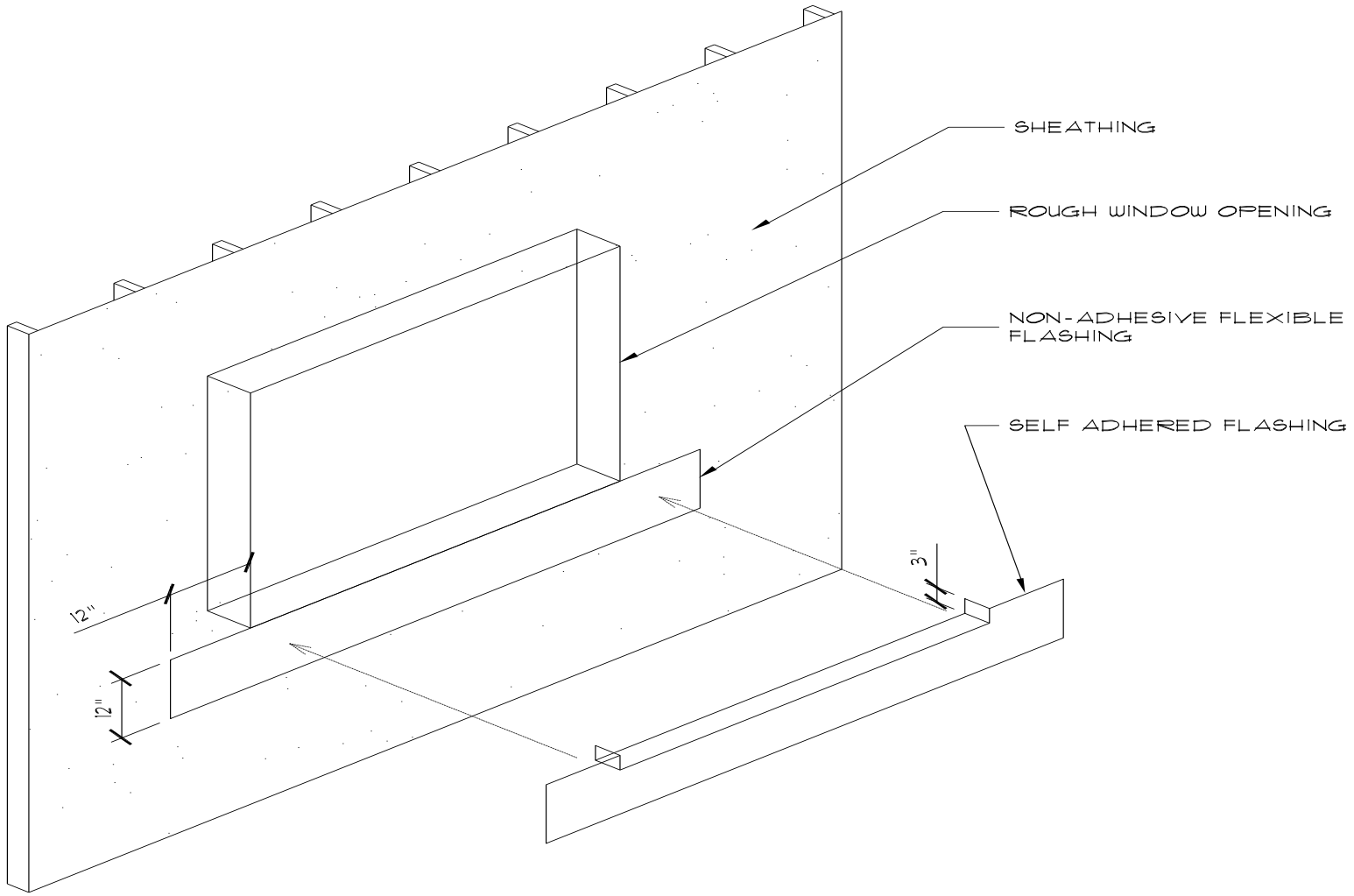
Karim P. Allana, P.E., RRC, RWC

Allana Buick & Bers, Inc.

ALLANA BUICK & BERS
Making Buildings Perform Better

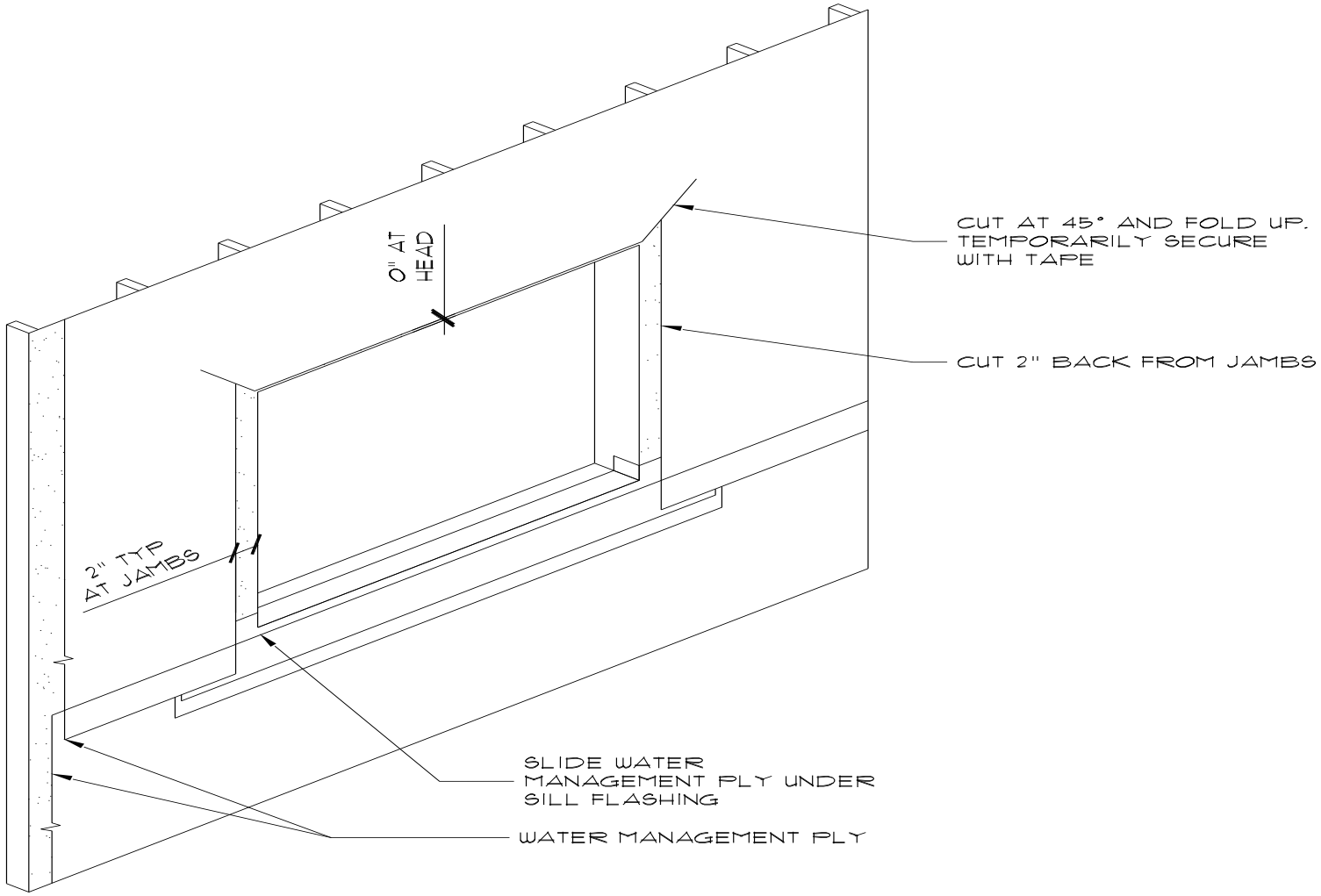
Flexible Flashing and Paper Integration

Fin Style Window



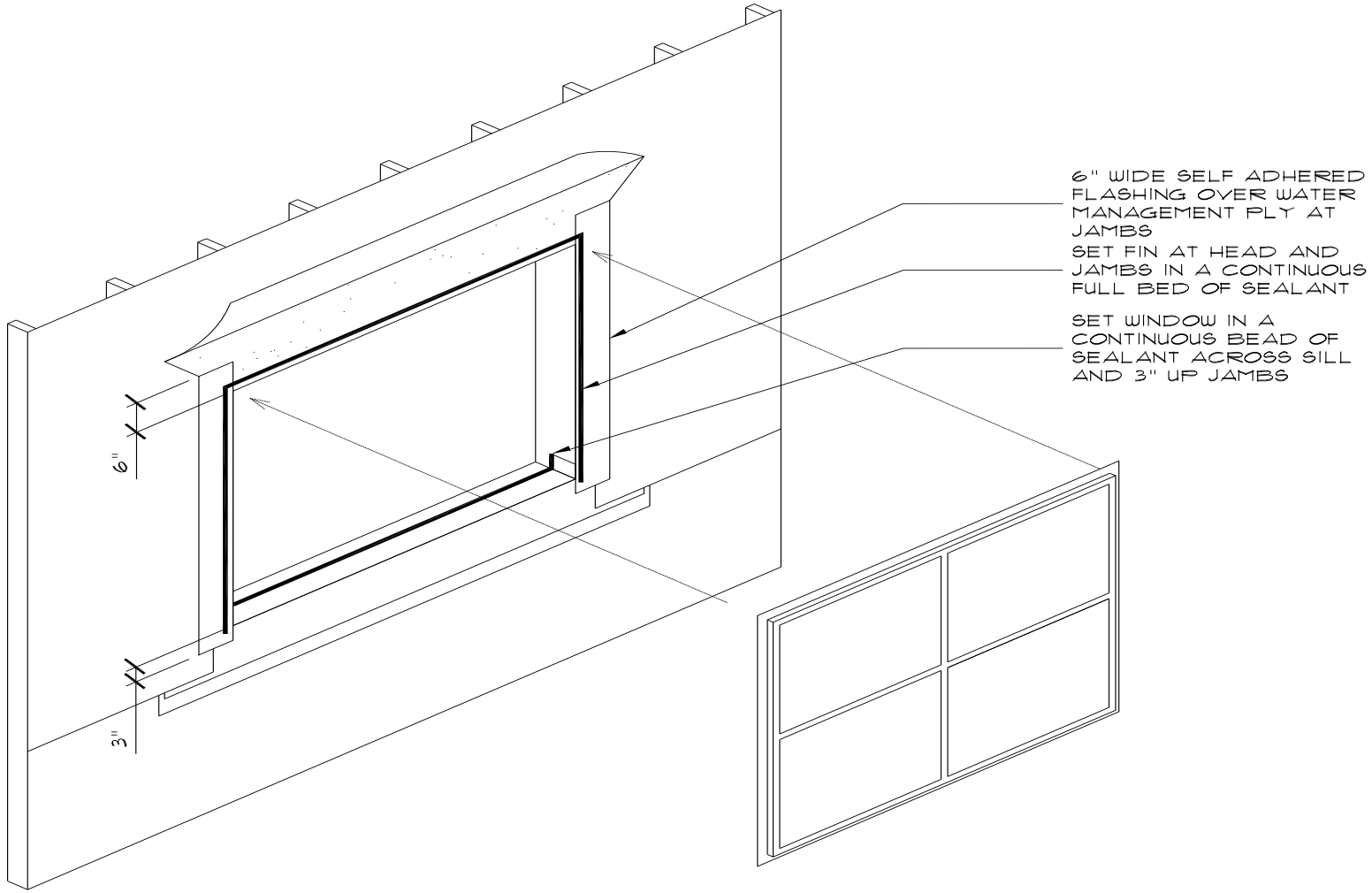
Window Flashing Sequence Step 1

Flexible Flashing and Paper Integration



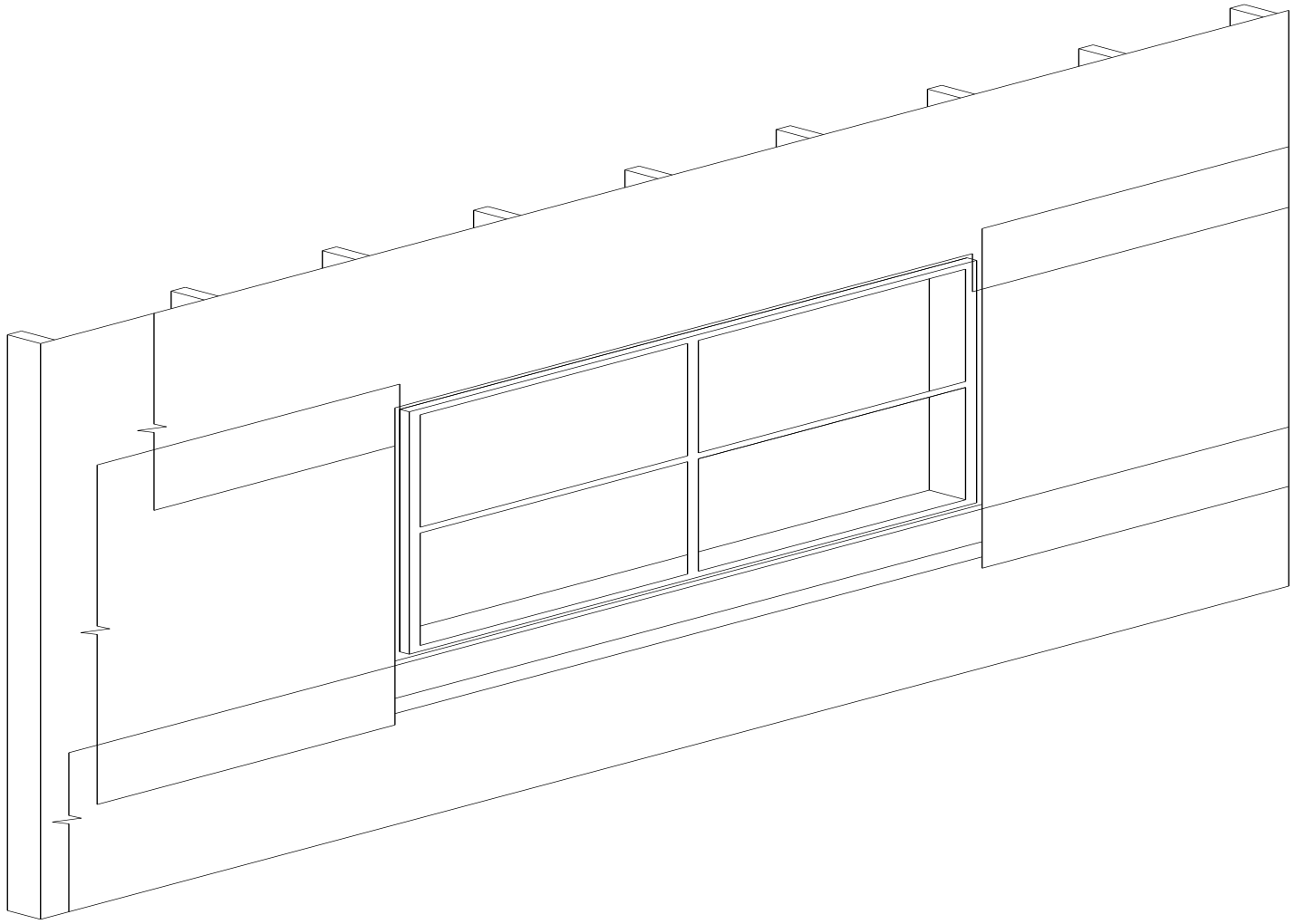
Window Flashing Sequence Step 2

Flexible Flashing and Paper Integration



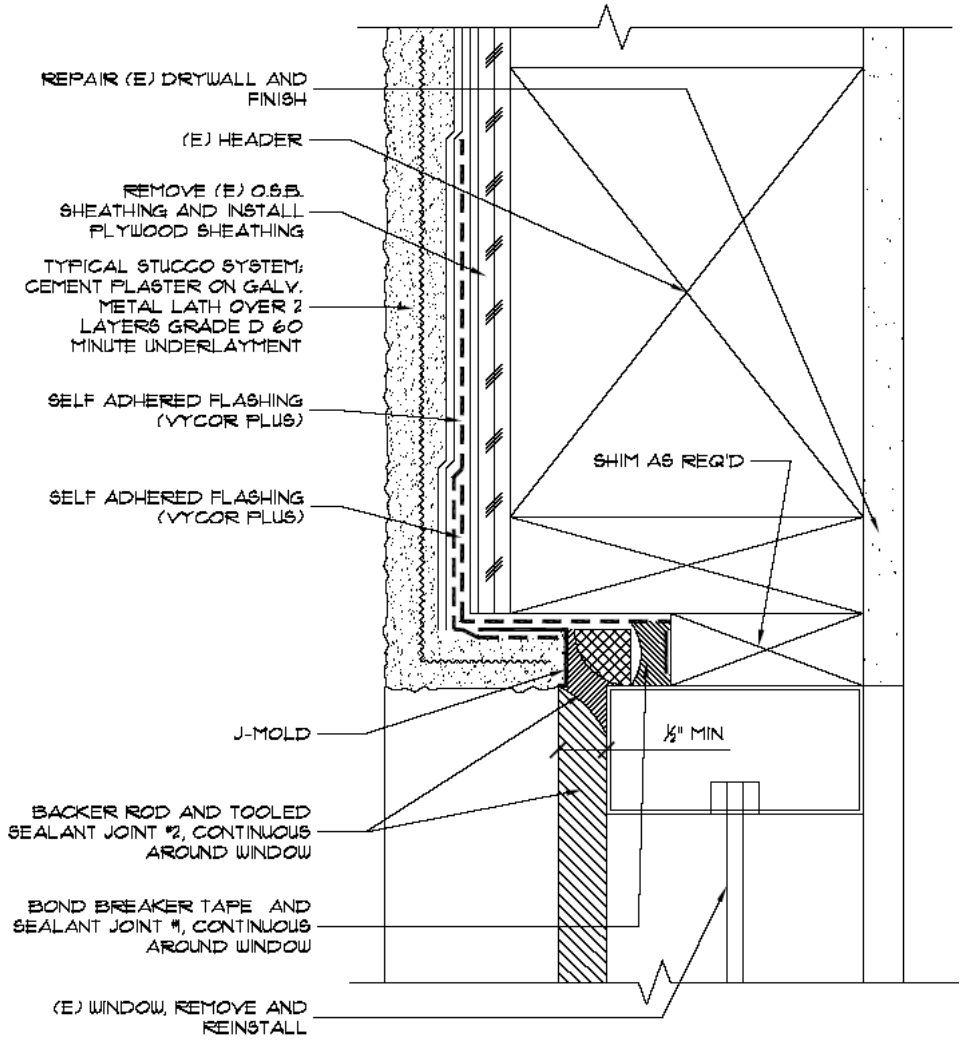
Window Flashing Sequence Step 3

Flexible Flashing and Paper Integration

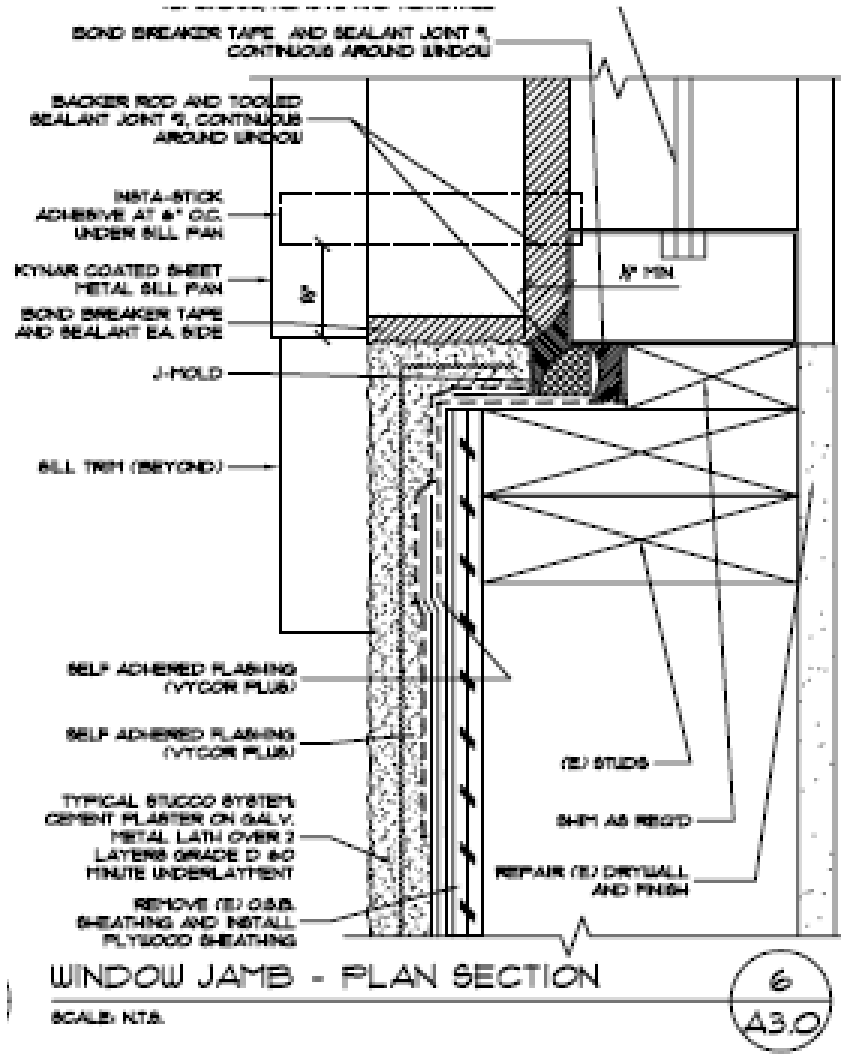


Window Flashing Sequence Step 7

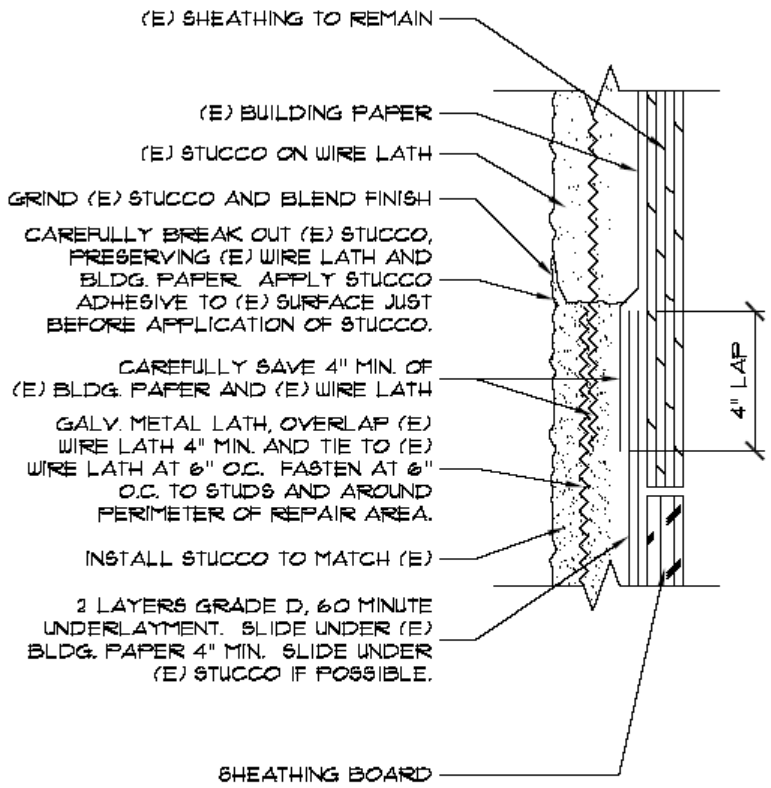
Storefront Stucco Integration



Storefront Jamb



Old to New Stucco Tie-in



STUCCO TIE-IN TO (E) STUCCO

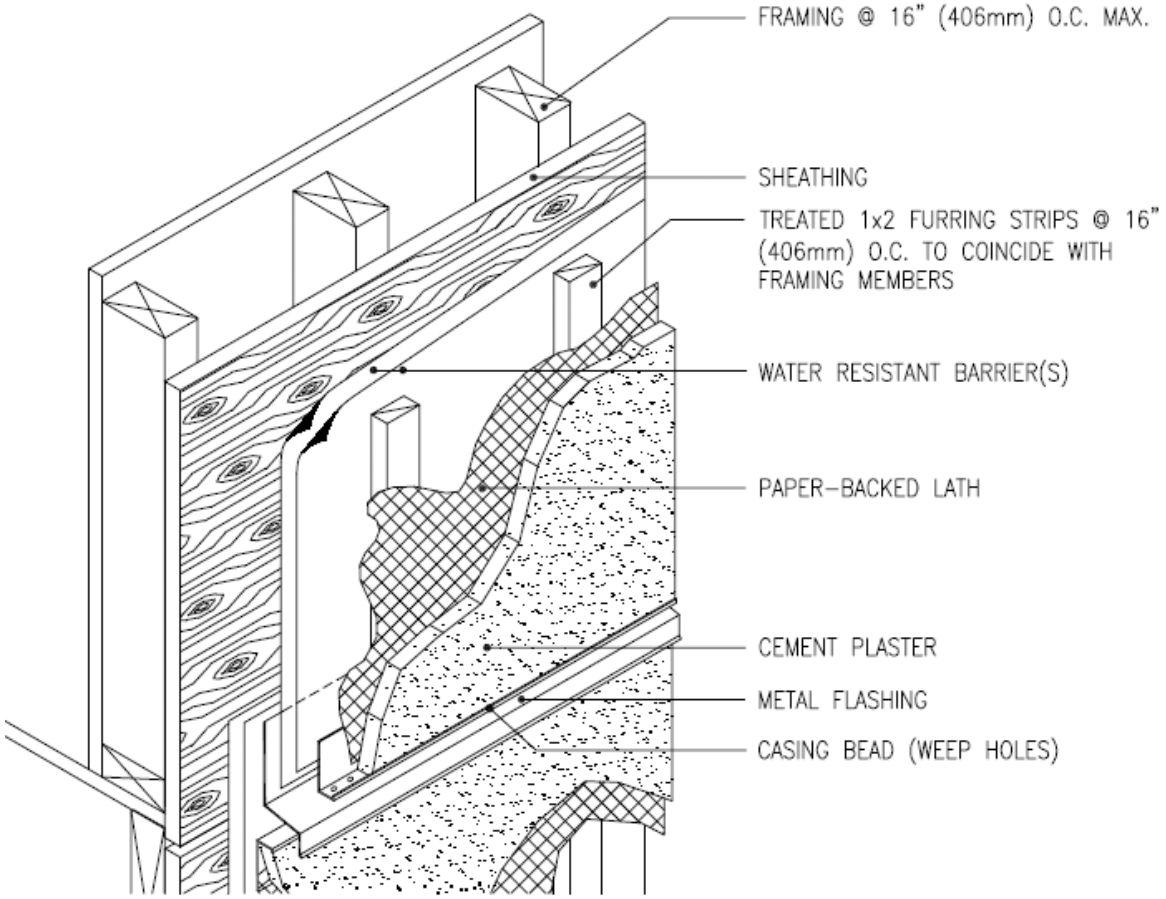
Typical Details
Rain Screen Stucco

Karim P. Allana, P.E., RRC, RWC

Allana Buick & Bers, Inc.

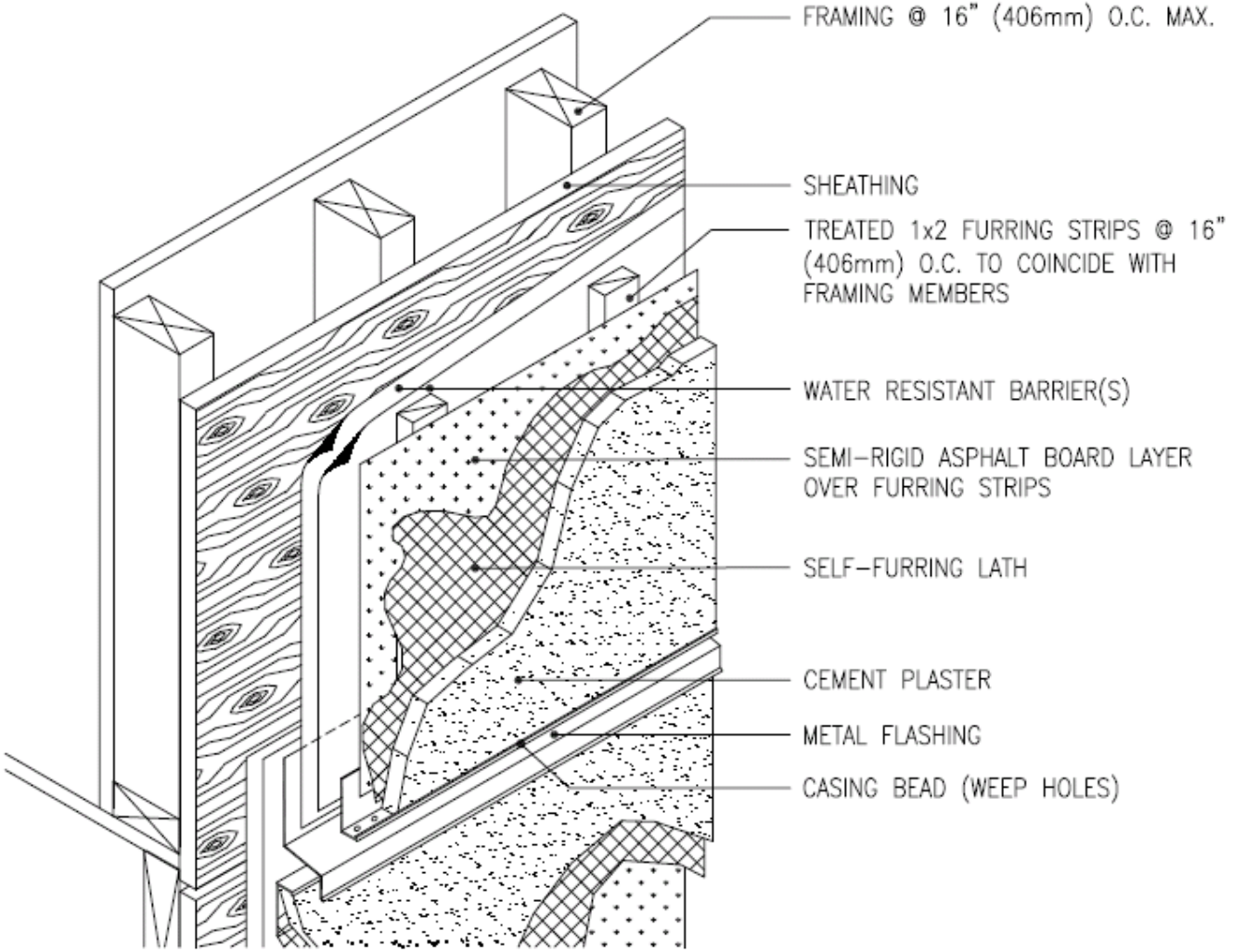
ALLANA BUICK & BERS
Making Buildings Perform Better

NWCB Traditional Rainscreen Stucco



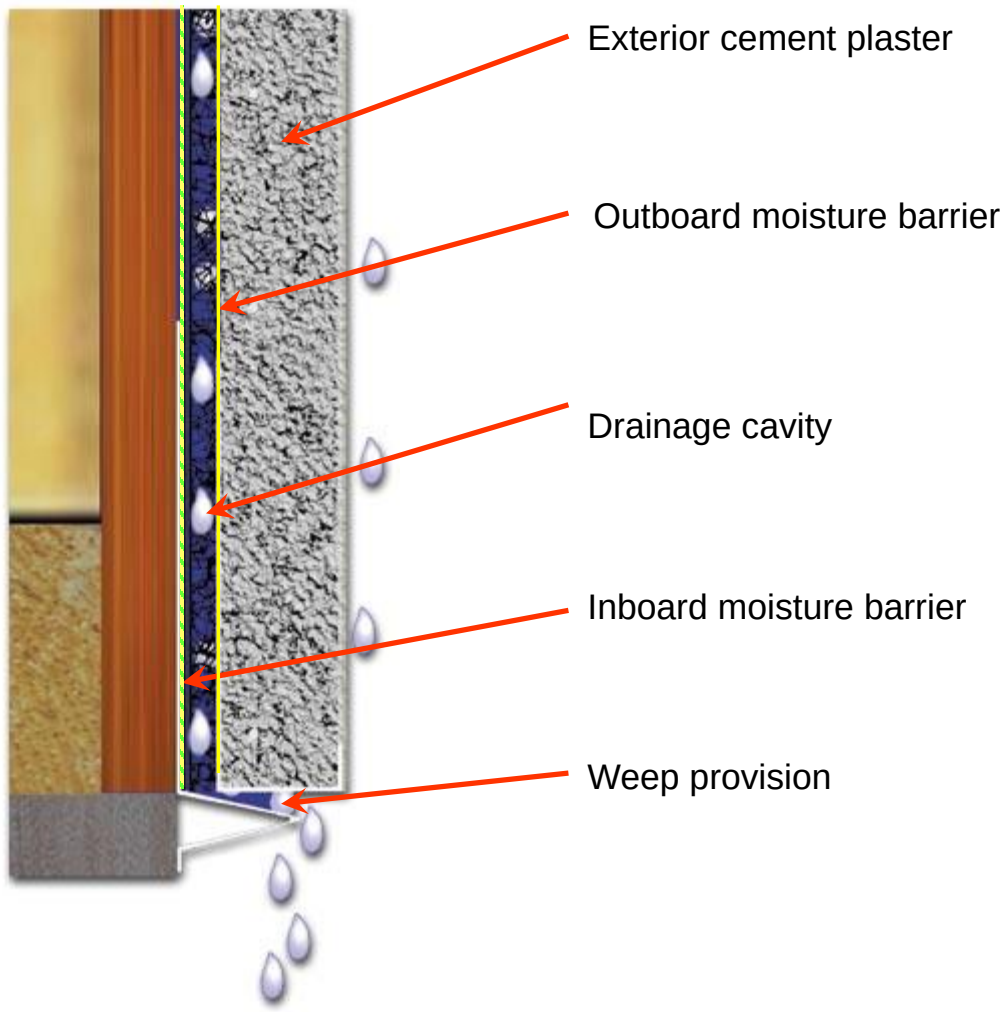
A11 – Opened Framed Rainscreen Construction

NWCB Semi-Rigid Rainscreen



A12 – Semi-Rigid Rainscreen Construction

Moisture Management/Rainscreen



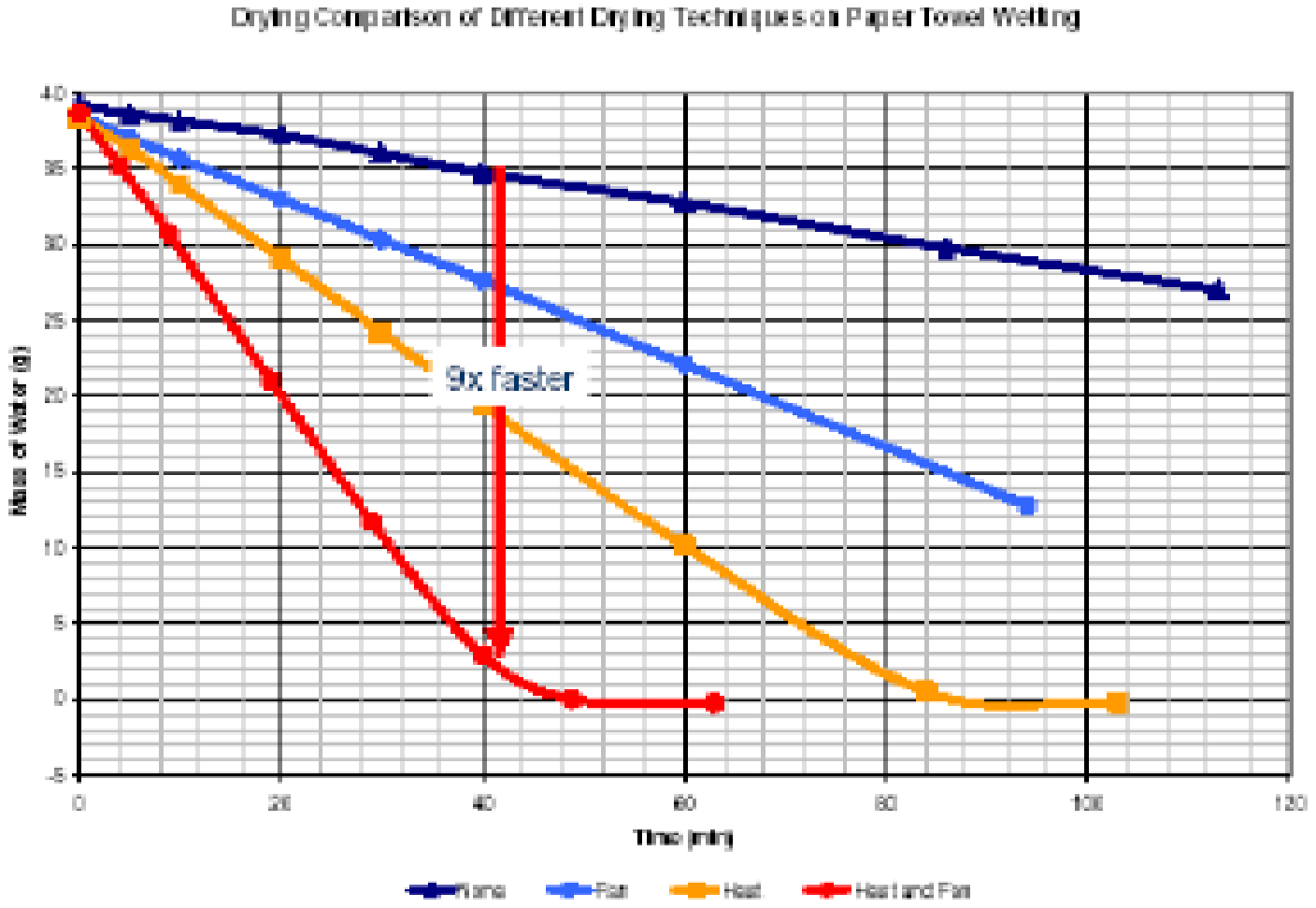
Moisture Management Drain Mat

Typical Drainage Cavity System “*Delta Dry*”

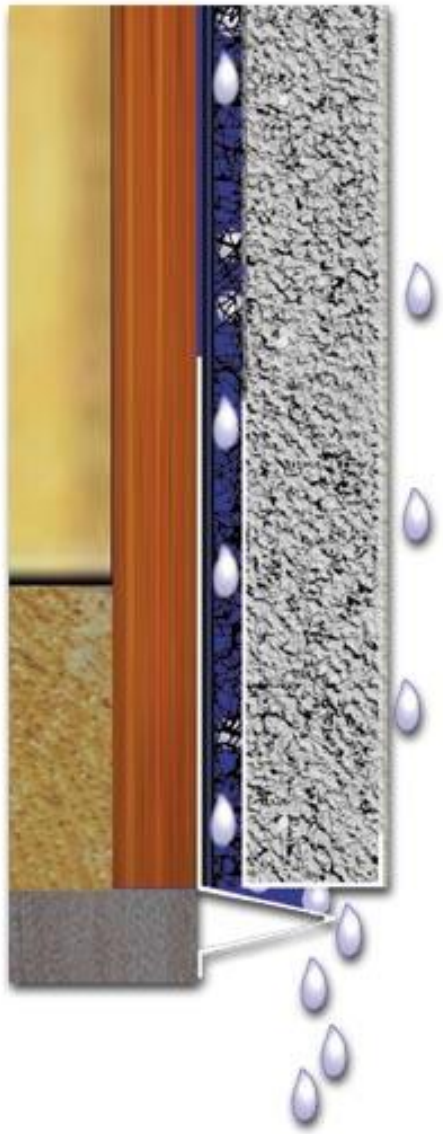
“Delta Dry” Drain Mat Uses

Drying Effects of Drainage (Delta Dry)

- Delta Dry claims that the wall dries 4 to 9 x faster:
-



Sucoflex Drain Mats



Drain Mats range from 3/16” to 3/8” thick, composite with geotextile fabric

THANK YOU!