BUILDING SCIENCE LIVE

FEBRUARY 16, 2022

Rainscreens: When, Where, and Why?

John Straube, PhD, P.Eng.
Principal, Senior Building Science Specialist

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Welcome!

- We are recording.
- Some FAQs:
  - You will get a follow-up email regarding how to access the recording and a pdf of slides.
  - **If you need a completion certificate for self-reporting or EPP and/or AIA or AIBC credits**, please follow the link in the chat box to let us know.
- Please use chat for housekeeping questions.
- Please use Q&A box for questions for the speaker.
  - We will break partway and at the end for questions.
  - Use upvote feature to let us know what you're most curious about!

More questions? Please contact us at events@learnbuildingscience.com.

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John Straube

PRINCIPAL, SENIOR BUILDING SCIENCE SPECIALIST

A prominent figure throughout North America, Dr. Straube is an influential and driving force in the industry. Well-known in a variety of building science and research circles, he helps guide the direction of RDH and is seen as a mentor to all levels of staff.

He has broad experience in the building industry and is considered an international expert, having been involved in the design, construction, repair, and restoration of buildings in Canada, the United States, Europe, Asia, and the Caribbean.

Dr. Straube is also known for his academic contributions as an Associate Professor in the Department of Civil Engineering and the School of Architecture at the University of Waterloo, where he teaches courses in structural design, material science, and building science to both disciplines.

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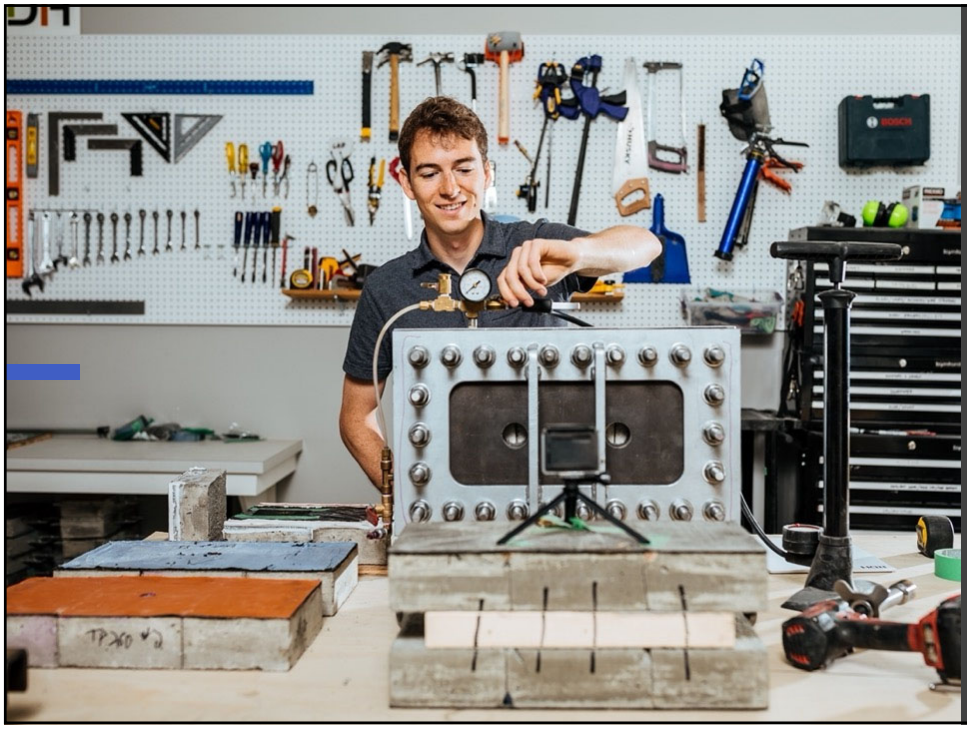

240+ staff

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Projects across North America

Focus on building science & building enclosures

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Today's presentation

- Some History
- "Rainscreens"… what are they, really
- Specifically, what are
  - Drained?
  - Ventilated?
  - Pressure-equalized?

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Poll Question: Where do you primarily practice or operate?

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SOME HISTORY

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Rain penetration control

- Transition of mass wall to drained was complex
- Pressure-equalized Rainscreen was proposed in the early 1960's
- Acceptance of drainage and WRB "drainage plane" took much longer

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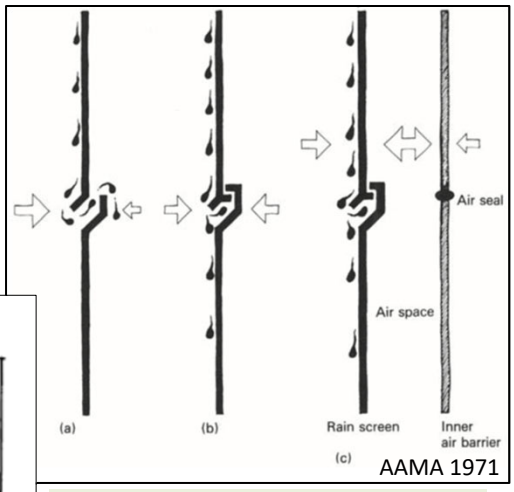
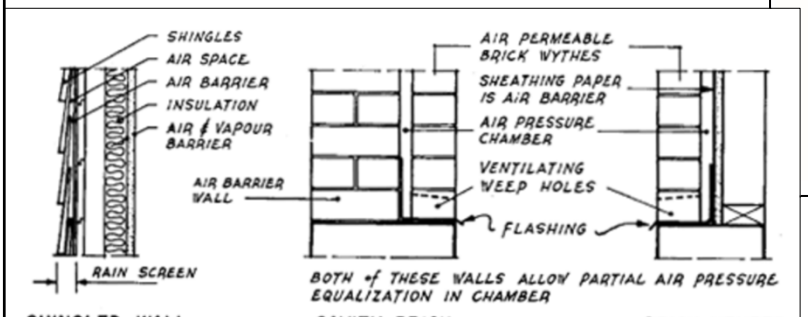
Rainscreen History

- Note, no WRB! But air barrier
- 1963 CDB 40 (below)- seminal
- 1971 AAMA Design Guide (right)



AAMA 1971



Garden, *Rain Penetration Control*, CBD40 1963.

Pressure equalization was the focus

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Svendsen 1967 "two-stage"

- No rainscreen, air barrier or WRB mentioned… but components look similar

"Two-stage weathertightening"

The principles of one-stage and two-stage seals
SVEN D. SVENDSEN,
NORWEGIAN BUILDING RESEARCH INSTITUTE
THE LABORATORY, TRONDHEIM, NORWAY

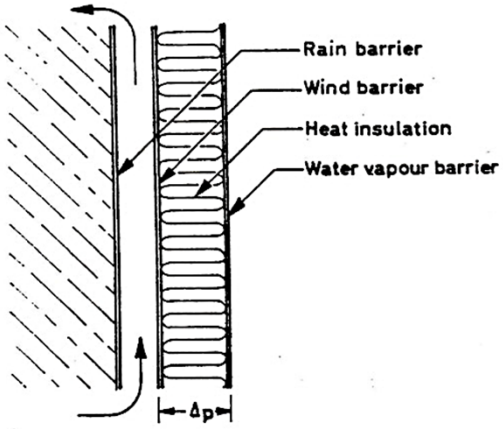

Fig. 3. The principle of two-stage seal.

Svendsen, S., 1967, "The principles of one-stage and two-stage seals". *Weathertight Joints for Walls: Proceedings of the International CIB Symposium,* pp. 25-28.

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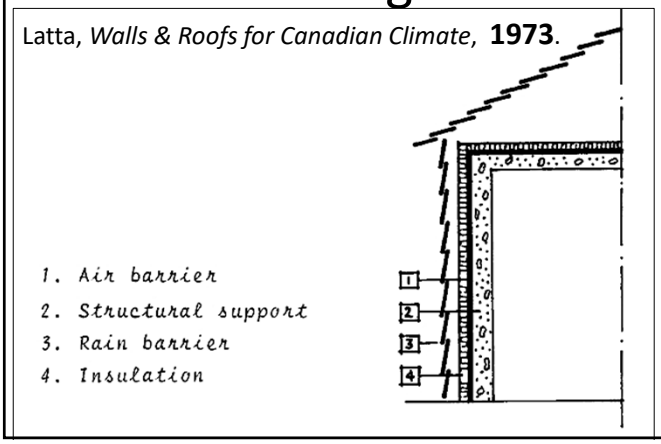
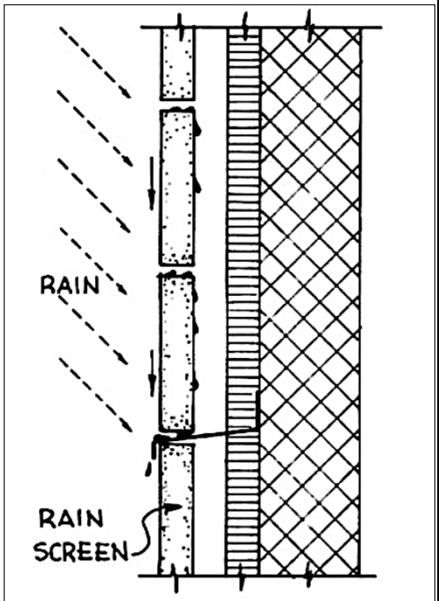
Still no WRB …

- Air barrier is there . . and flashing

Latta, *Walls & Roofs for Canadian Climate*, **1973**.





Max Baker, *Roofs*, **1980**.

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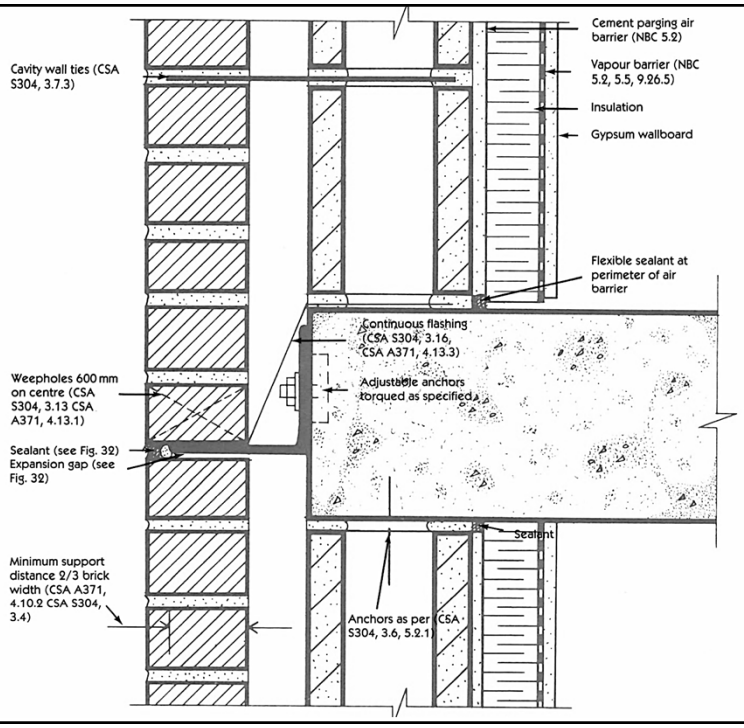
1981 CMHC Masonry Guide

- No WRB
- But… Air + Vapor barriers

Plewes, W.G. 1981. *Exterior Wall Construction in High-Rise Buildings*. Advisory Document. Canada Mortgage & Housing Corporation, 1981. 73 pp.



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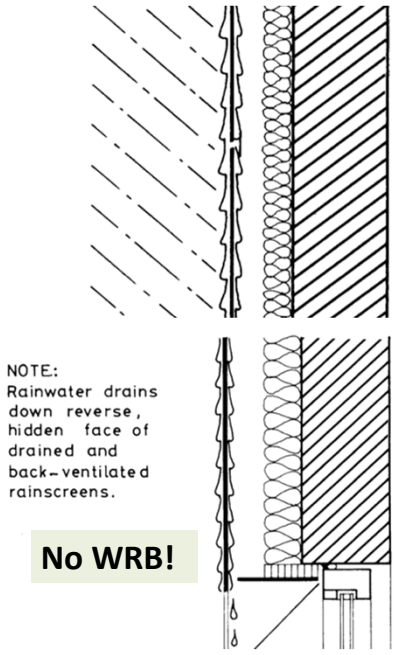
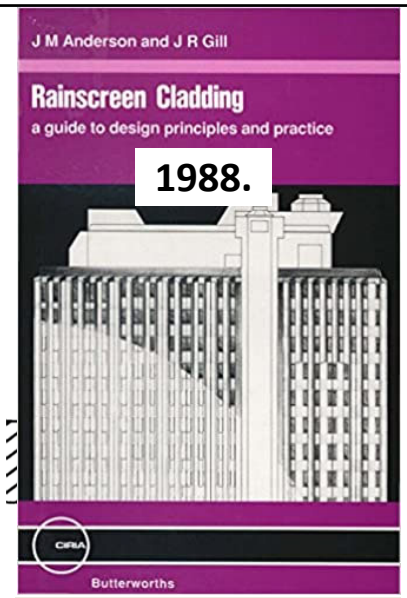


No WRB!



Explicitly separated drainage+ ventilation from pressure equalization

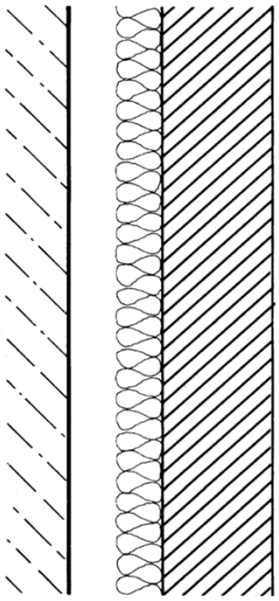


Figure 12 The protective function of the rainscreen in a two-stage wall

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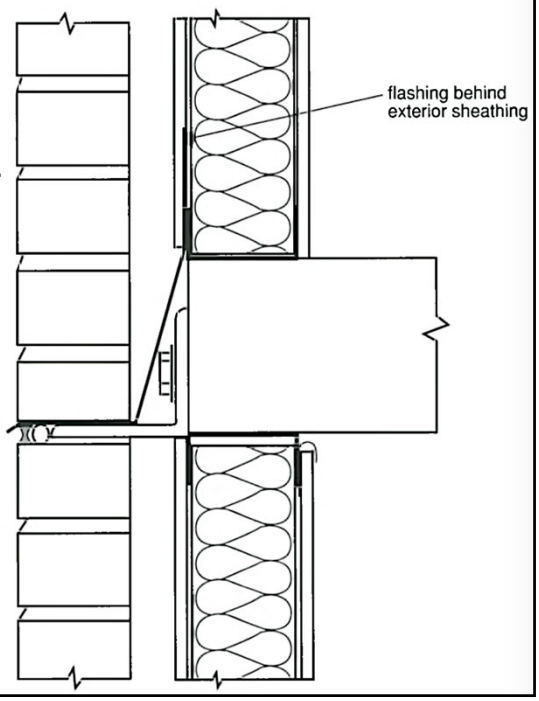
1991 CMHC Guide

- High-rise steel stud w/ exterior *paper-faced exterior gypsum!* and no WRB
- The recommendation in 1991

Drysdale and Suter, 1991. *Exterior wall construction in high-rise buildings: brick veneer on concrete masonry or steel stud wall systems*, guide for CMHC, 1991.



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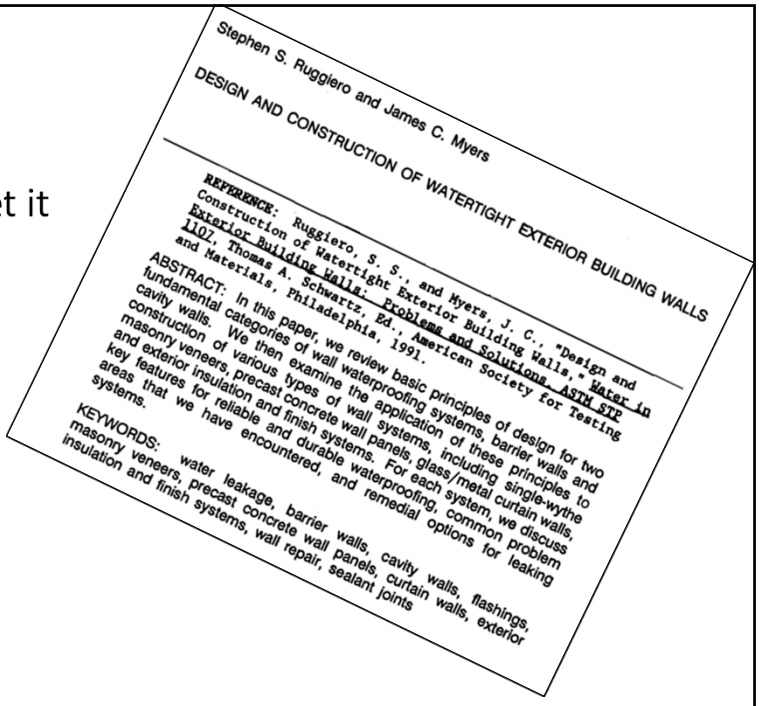
1991 ASTM

- Practitioners start to get it

"Our experience in evaluating and testing various wall systems is that much of the leakage can be replicated by allowing water to flow over the wall system without application of a differential pressure across the wall"


Stephen S. Ruggiero and James C. Myers

DESIGN AND CONSTRUCTION OF WATERTIGHT EXTERIOR BUILDING WALLS

REFERENCE: Ruggiero, S. S., and Myers, J. C., "Design and Construction of Watertight Exterior Building Walls," Water in Exterior Building Walls: Problems and Solutions, ASTM STP 1107, Thomas A. Schwartz, Ed., American Society for Testing and Materials, Philadelphia, 1991.

ABSTRACT: In this paper, we review basic principles of design for two fundamental categories of wall waterproofing systems, barrier walls and cavity walls. We then examine the application of these principles to construction of various types of wall systems, including single-wythe masonry veneers, precast concrete wall panels, glass/metal curtain walls, and exterior insulation and finish systems. For each system, we discuss key features for reliable and durable waterproofing, common problem areas that we have encountered, and remedial options for leaking systems.

KEYWORDS: water leakage, barrier walls, cavity walls, flashings, masonry veneers, precast concrete wall panels, curtain walls, exterior insulation and finish systems, wall repair, sealant joints

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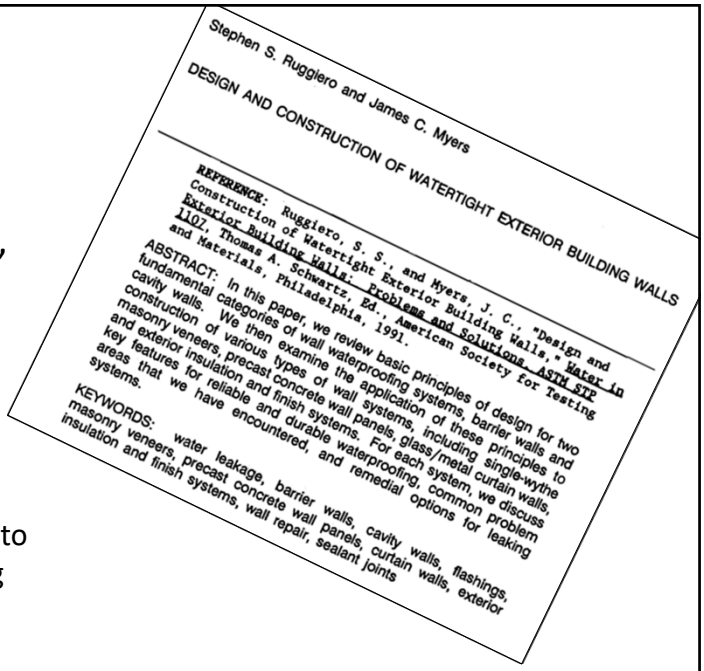
1991 ASTM

- Practitioners start to get it
- "Drained" & "Cavity Walls" are defined

"the exterior surfacing screens the rain from the waterproofing layer that is placed behind it"

"include a back-up waterproofing system to collect water that penetrates the cladding surface and drain it back outside"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KEYWORDS: water leakage, barrier walls, cavity walls, flashings, masonry veneers, precast concrete wall panels, curtain walls, exterior insulation and finish systems, wall repair, sealant joints

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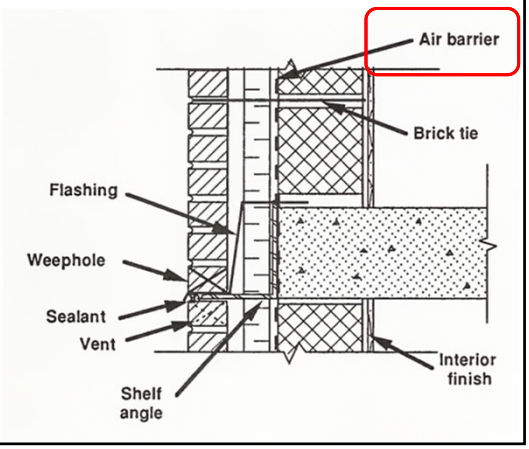
1993 NIST Guide - Dr A Persily

- "…good masonry construction for rain penetration should be supplemented by the use of a facade or veneer that provides a second line of defense combined with a drainage system to remove the water that penetrates the facade."
- "… flashing must be properly installed at all required locations, the cavity must be well drained and the backup wall must be airtight and watertight."



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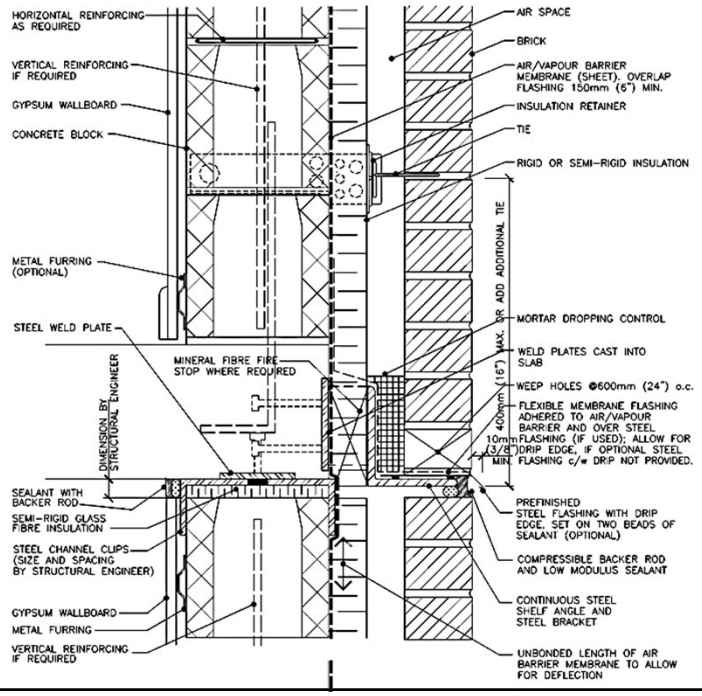

CMHC 1997

AIR/VAPOUR BARRIER MEMBRANE (SHEET). OVERLAP FLASHING 150mm (6") MIN.

Excellent modern detailing, but still water control layer not *labelled*

From: CMHC Best Practise *Guide. Brick veneer concrete masonry unit backing*. 1997.

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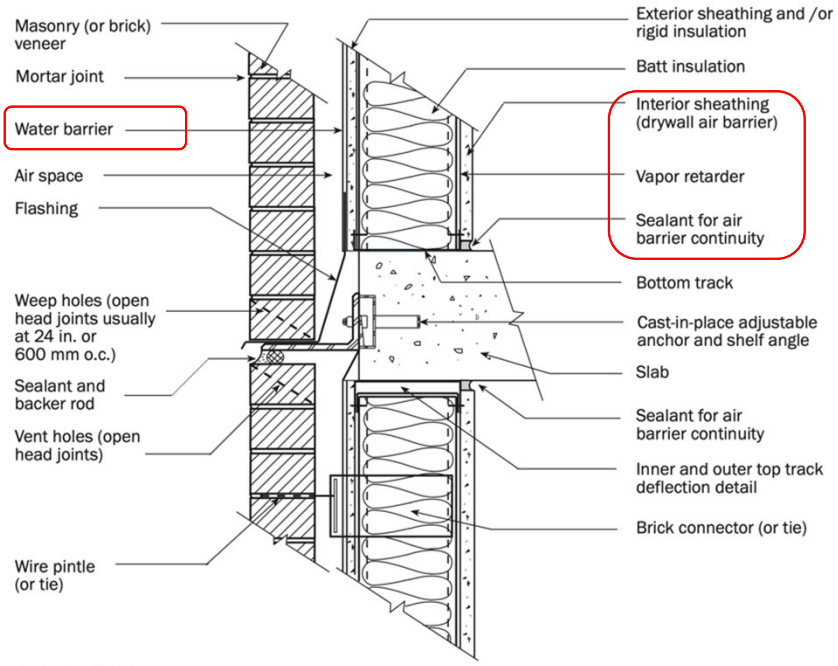

Finally, AISI 2003

Trestain, T.W., *Steel Stud Brick Veneer Design Guide*, AISI 2003.
and
Trestain, T.W., *Steel Stud Brick Veneer Design Guide*,CSSBI 2007.

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Today (2022)

- We know (?) we need **water** *and* **air** barriers
- But ….
  - Water control layers (WRB) are still often not labelled on drawings
  - Air barriers often confused with water barriers
  - Water barriers often confused with air barriers
  - Vapor barrier still confused with air barriers

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Chat Question:
What size of an air gap do you typically include within your rainscreen wall designs?

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Rainscreen

- Once meant: cladding that “screens” rain
  - i.e., “cladding that leaks rain”
- Then “pressure equalized rainscreen”
- Now… ventilated cladding?

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Enclosure Rain Control Strategies

- Assume: rainwater is likely on the wall
- We know: water can penetrate in many ways

Three fundamental approaches …

- **Drainage**
- **Exclusion**
- **Storage**

A total of <u>three</u> fundamental approaches

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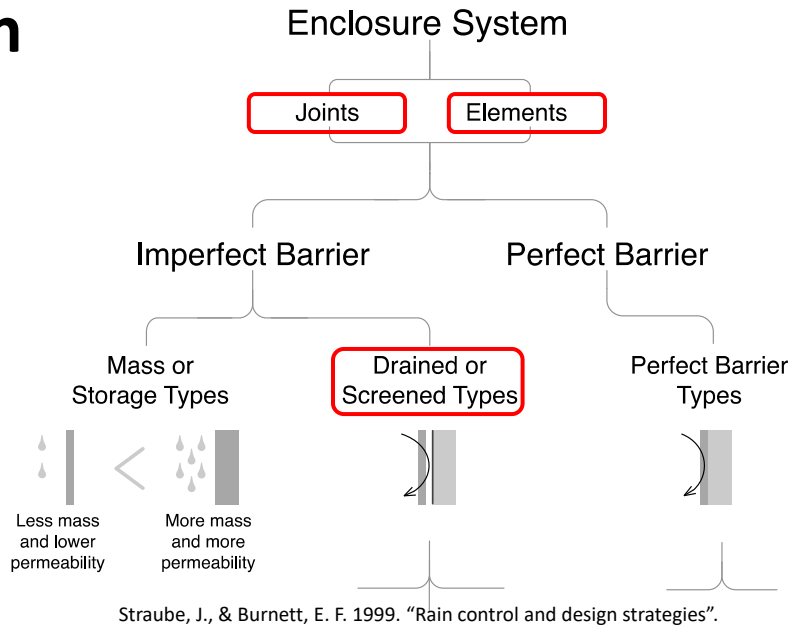
Categorization

- Elements and joints can be different
- System developed using science, not forced to fit standard walls



Straube, J., & Burnett, E. F. 1999. "Rain control and design strategies". *Journal of Thermal Envelope and Building Science*, *23*(1), 41-56.

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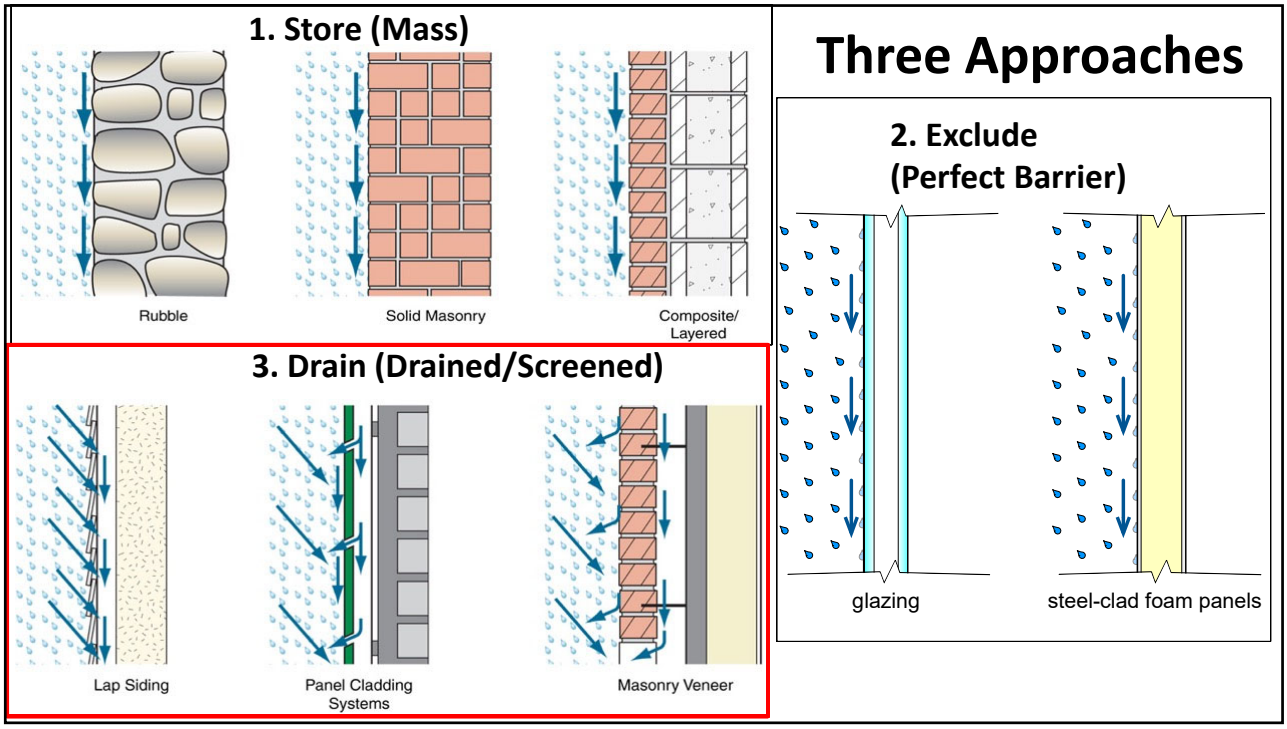
1. Store (Mass)
Rubble
Solid Masonry
Composite/ Layered
3. Drain (Drained/Screened)
Lap Siding
Panel Cladding Systems
Masonry Veneer
Three Approaches
2. Exclude (Perfect Barrier)
glazing
steel-clad foam panels

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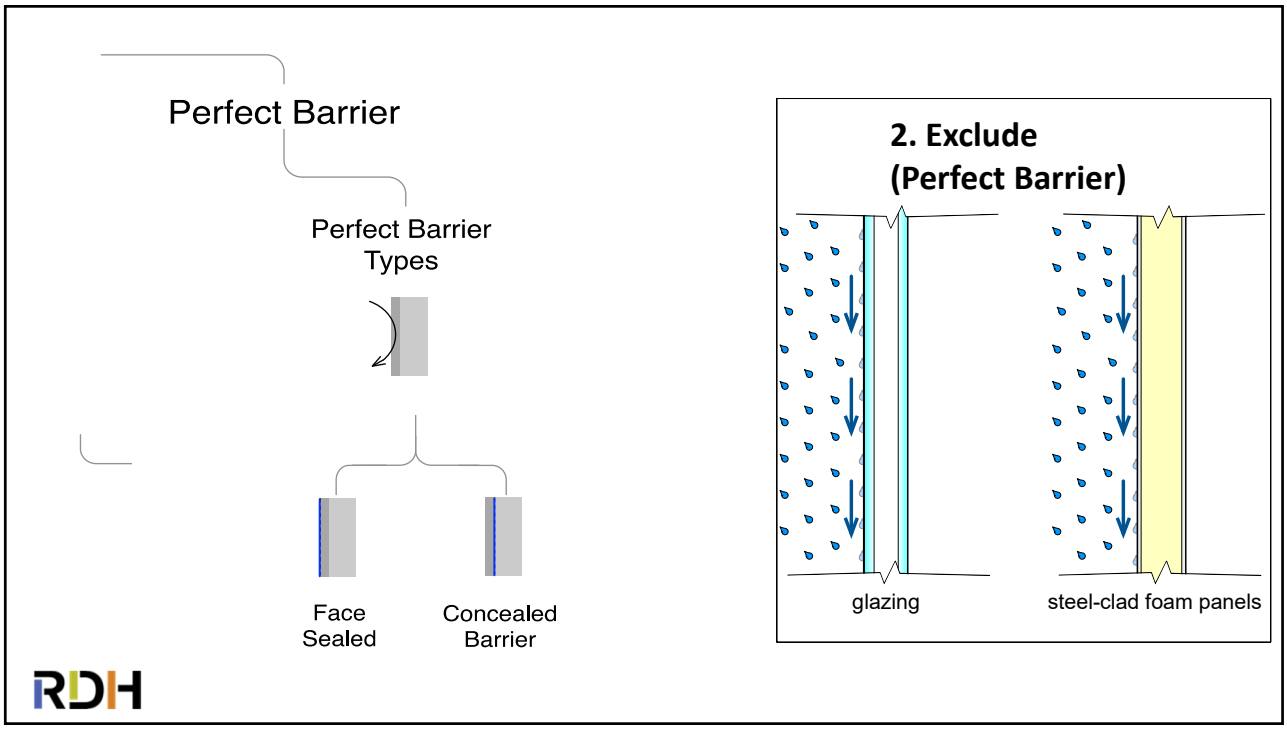
Perfect Barrier
Perfect Barrier Types
Face Sealed
Concealed Barrier
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2. Exclude (Perfect Barrier)
glazing
steel-clad foam panels

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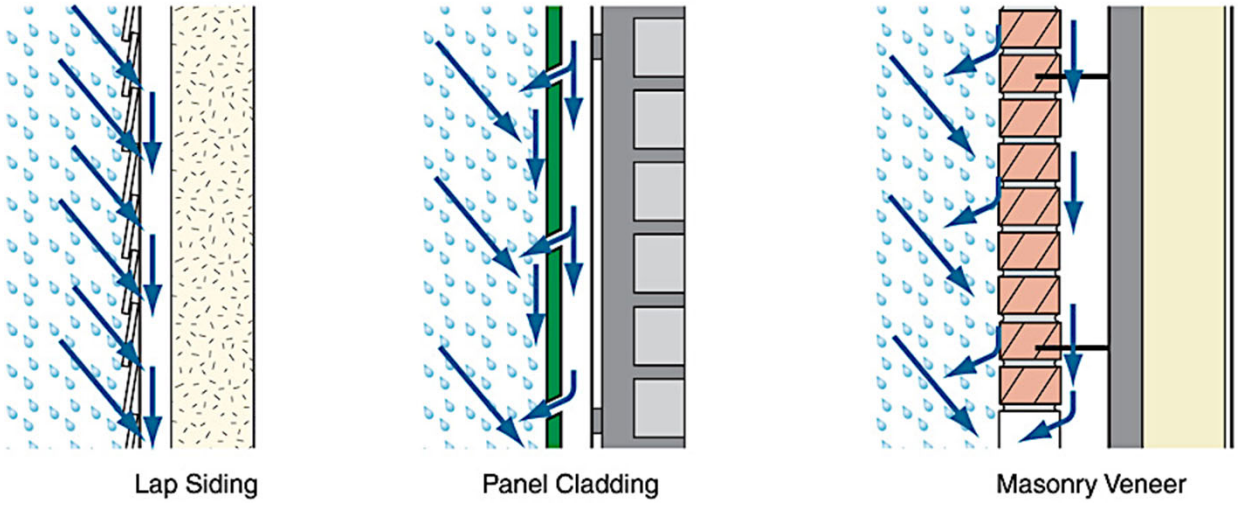
Drained Walls

Historically, all labelled as rainscreens sometime



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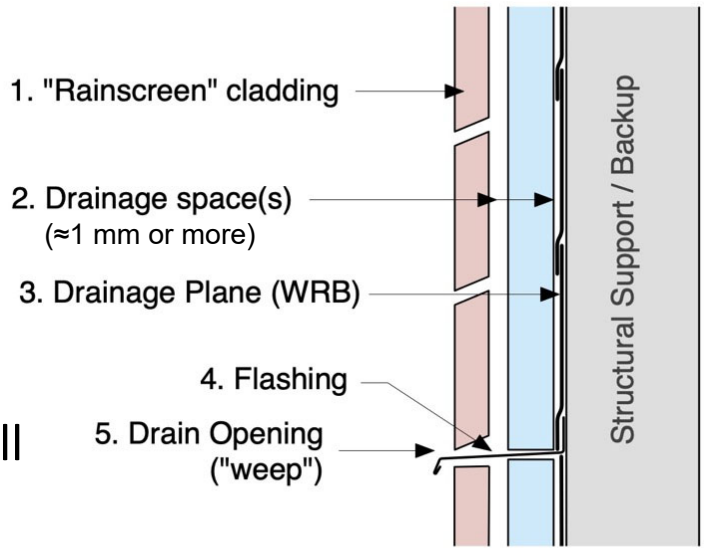
Drained

- 5 components
- No air barrier required
  - But air barrier, insulation, etc all needed in a modern wall



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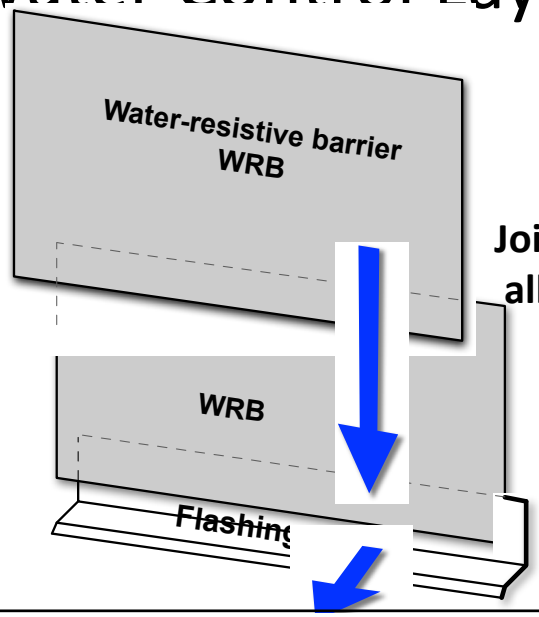
Lapped Water Control Layer



Joints lapped to allow drainage

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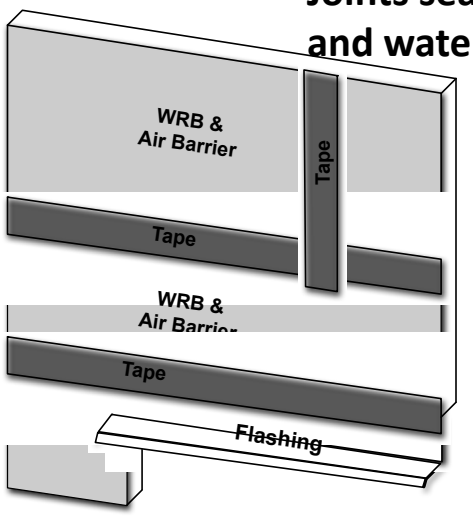
Combined air & water control

Joints sealed air and water tight



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So what *is* a Rainscreen?

- A **drained** wall ***always has drainage***
  and **may** also have
- Large (>6?mm) gap to prevent bridging

and/or

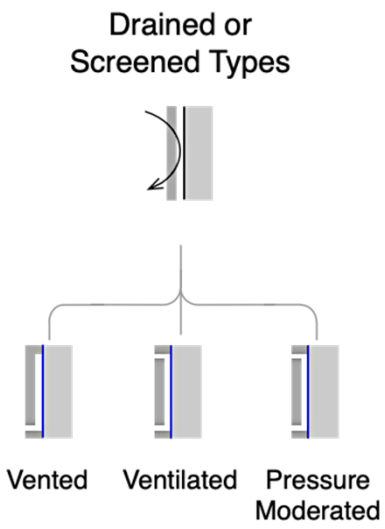
- Venting

and/or

- Ventilation (does this mean a large gap?)

and/or

- Pressure Equalization (this means?)



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The most important and fundamental feature of rainscreens

DRAINAGE & GAPS

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Drainage gaps

- Small cracks can allow water to leak past cladding

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Drainage gaps

- Small cracks can allow water to leak past cladding
- Small gaps *also* allow drainage

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Drainage gaps

- Small cracks can allow water to leak past cladding
- Small gaps *also* allow drainage
- Question: How small?
  Answer: In the range of 1/16” and smaller

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IRC/NRC Testing 2000

Brown, W. C., Chown, G. A., Poirier, G. F., & Rousseau, M. Z. (1999). Designing exterior walls according to the rainscreen principle. Construction Technology, 34, 1-8.

Size of Cavity Required for Effective Drainage[15,16]

IRC conducted rain penetration tests on four full-scale wood-frame wall specimens with windows. Test parameters included type of cladding used for the first line of defence, and size of cavity and type of sheathing membrane used in the second line of defence. The windows were installed in flashed and drained rough openings, and sealed on the exterior. Water penetration was measured both with and without static and dynamic pressure differences across the specimens, and with several degrees of defect in the sealant, typical of those defects observed in the field.

The first three specimens were clad with 12-mm cement board with synthetic stucco finish, and installed over

- 12-mm cement board furring strips over asphalt-impregnated paper over oriented strand board (OSB), providing a 12-mm deep cavity (Figure 7).
- asphalt-impregnated paper over OSB. The space between the cement board and the paper provided the cavity (Figure 8).
- 3-mm plastic furring strips over asphalt-impregnated paper over OSB, providing a 3-mm deep cavity (Figure 9).

The fourth specimen was clad with 25-mm expanded polystyrene (EPS) with a synthetic stucco finish, and installed over a continuous layer of 3-mm plastic furring over asphalt-impregnated paper over OSB (Figure 10).

All specimens, including the one without a furred cavity, effectively drained a considerable amount of water that entered around and through the windows. However, a large amount of water was absorbed and retained in the cement board cladding in specimens 1, 2 and 3.

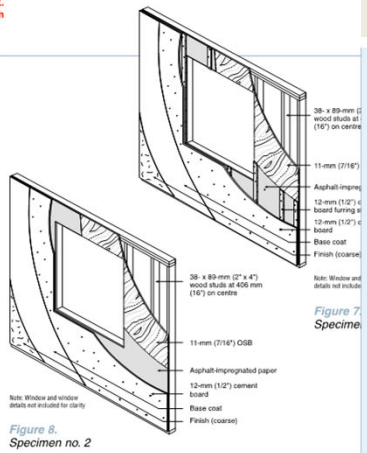

Figure 8.
Specimen no. 2

Conclusion

“All specimens, including the one without a furred cavity, effectively drained a considerable amount of water that entered around and through the windows.”

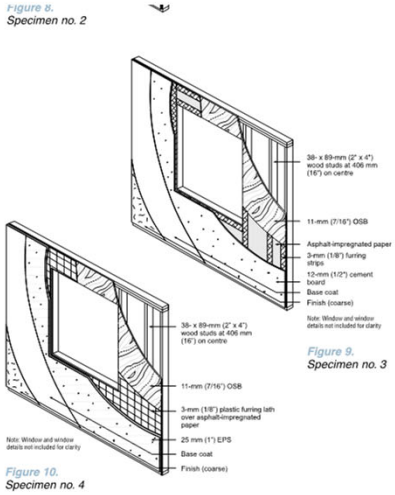

Figure 9.
Specimen no. 3

Figure 10.
Specimen no. 4

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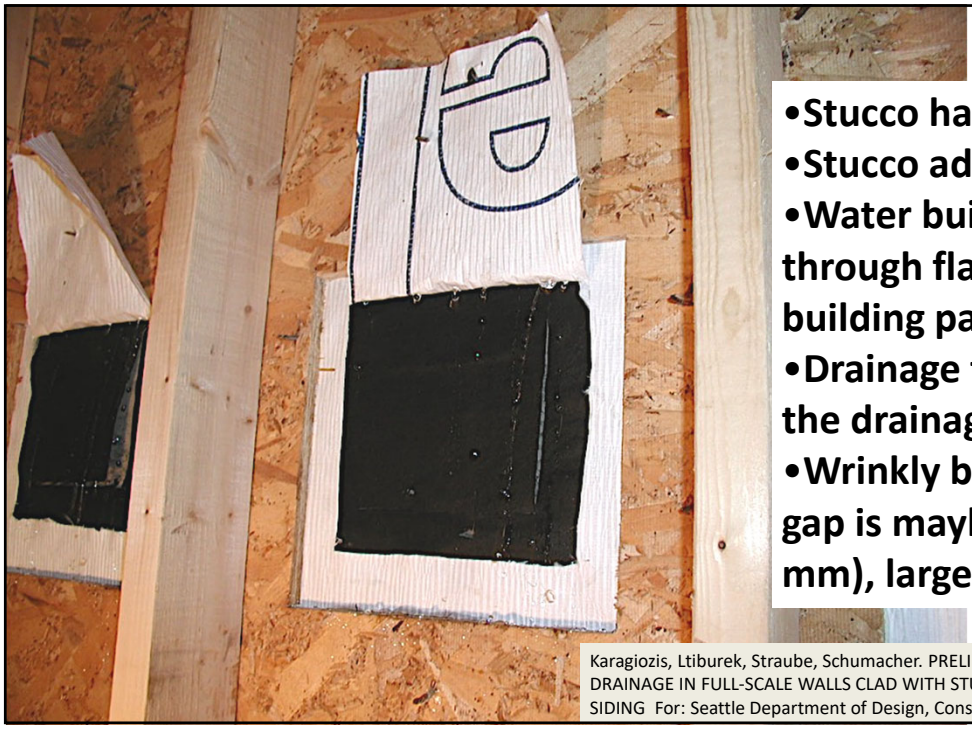

- **Stucco has cracks**
- **Stucco adheres to paper**
- **Water builds up & presses through flaws in the building paper**
- **Drainage then occurs in the drainage gap provided**
- **Wrinkly building paper gap is maybe 15 mil (0.4 mm), larger at nail heads**

Karagiozis, Ltiburek, Straube, Schumacher. PRELIMINARY INVESTIGATION OF DRAINAGE IN FULL-SCALE WALLS CLAD WITH STUCCO AND HORIZONTAL VINYL SIDING For: Seattle Department of Design, Construction and Land Use , 2002.

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Many roles for the gap

- Gap avoids hydrostatic pressure
  - if >0.3 mm / 12 mil (approximately)
  - drains water away, avoids hydrostatic pressure
- *May* prevent bridging
  - if > 1/8" (>3 mm) based on droplet size
- Can allow ventilation drying
  - If >> 1/8"(3mm), but likely needs over 1/2"

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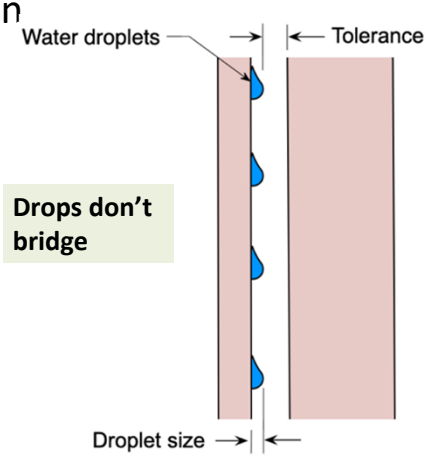
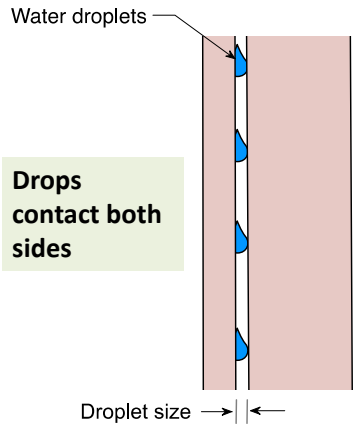
Bridging of air gap

- Droplets less than ≈3mm, but tolerance often added to recommendation

But, why don't we want water on the WRB?





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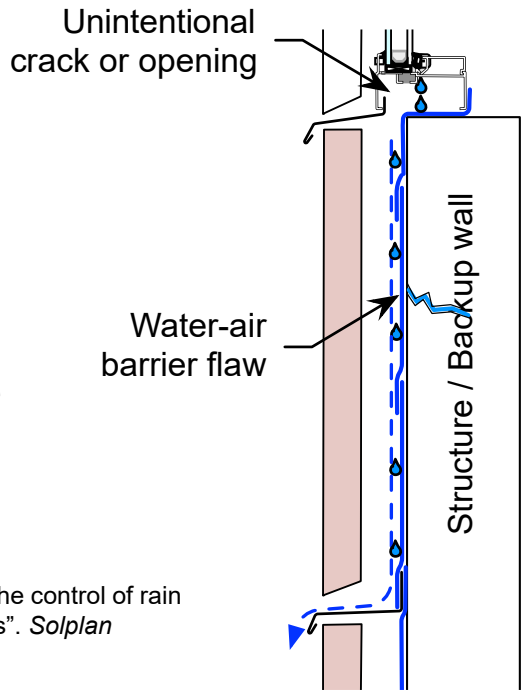
Rainwater enters primarily at penetrations, and hence often onto WRB directly… so is moisture bridging important?

"Even when an air space was present behind the cladding system, it was beneficial . . . for second line of defence, be it a water-resistive membrane or a board stock material, be attached in a water-resistant manner."



Lacasse, M. A., 2004. "IRC studies on the control of rain penetration in exterior wood-frame walls". *Solplan Review*, 114, pp. 14-15.

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Let's check the Q&A

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The best reason for bigger cavities

VENTILATION

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Why ventilation

- Allow **drying** of:
  - Back of cladding
  - Inside drainage cavity
  - Sheathing (if vapor permeable WRB)
- **By-pass** vapor resistance of cladding
  - Cold weather condensation / drying

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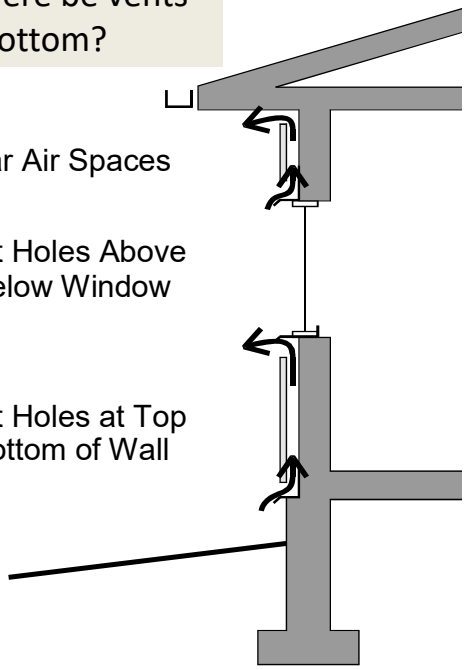
Ventilated Walls

Must there be vents top & bottom?

Ventilation provides drying to the exterior

Can be important for:

1. **vapor impermeable cladding**
   - e.g., metal panels, glazed tiles, etc.
   - bypass vapor resistance / avoid condensation
2. **systems which store rainwater**
   - manage inward vapor drives, dry wet cladding
3. **Moisture-sensitive cladding**
   - esp. wood, fiber-cement drying backside



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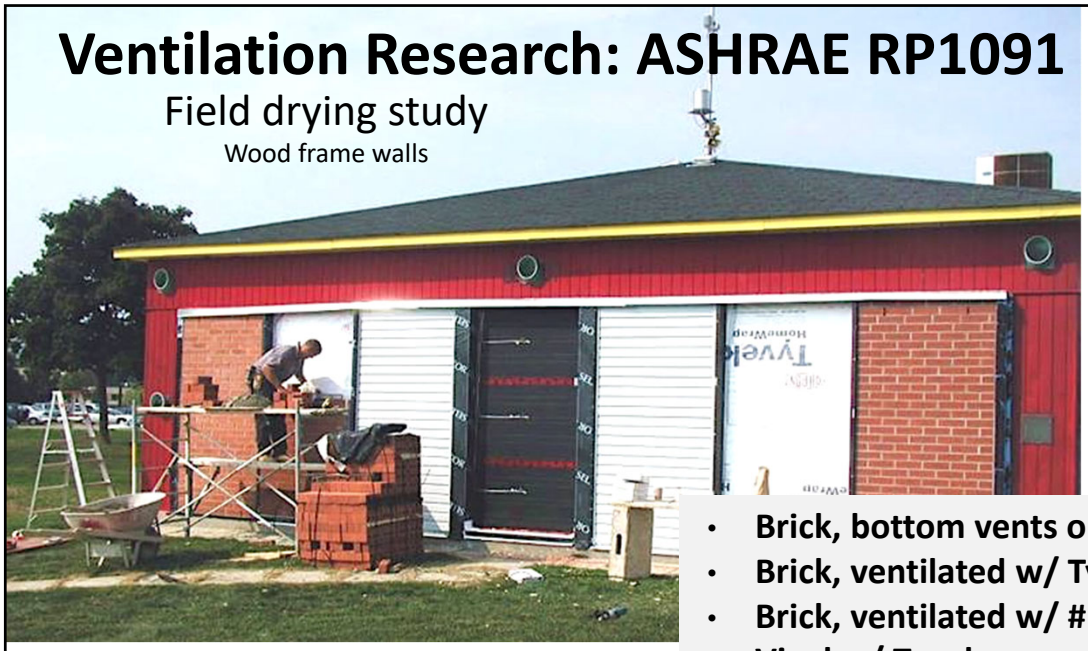
Ventilation Research: ASHRAE RP1091

Field drying study

Wood frame walls



- Brick, bottom vents only w/ Tyvek
- Brick, ventilated w/ Tyvek
- Brick, ventilated w/ #15 Felt paper
- Vinyl w/ Tyvek
- Vinyl w/ #15 Felt

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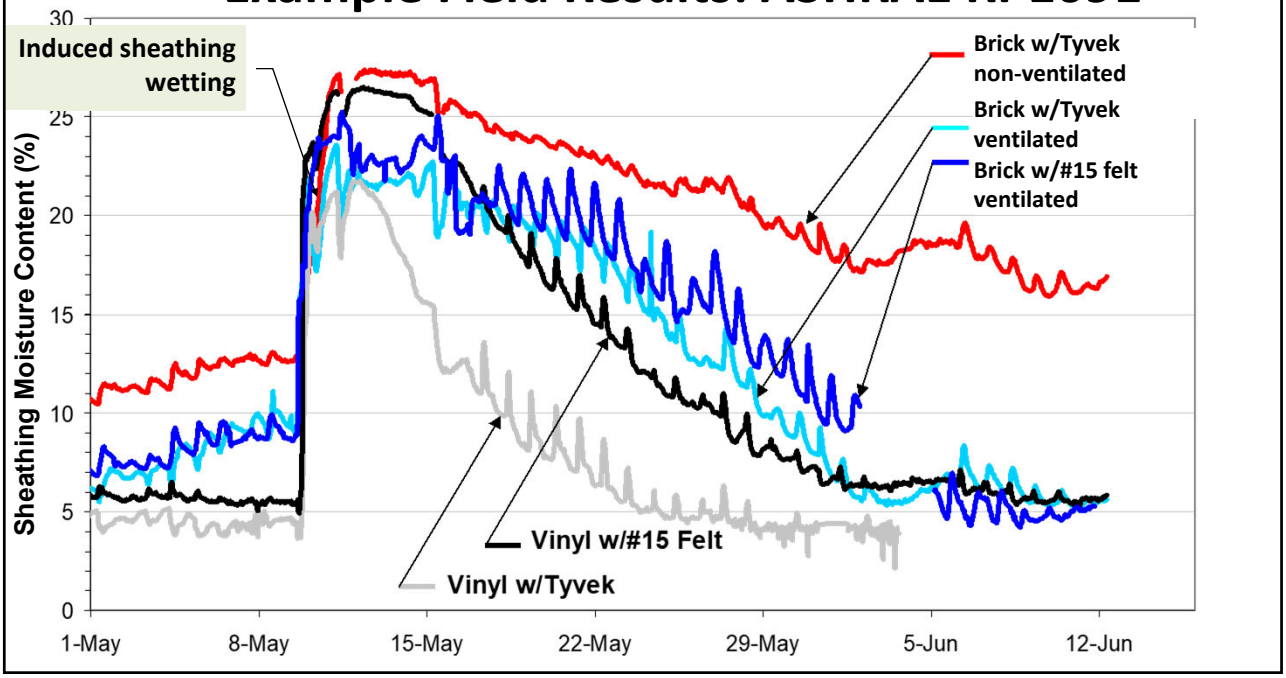
Example Field Results: ASHRAE RP1091



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Rainscreen Euro-Con-fusion

E.g. SwissPearl (2019)
Gap & ventilation *but:*
- *no WRB!*
- *no mention of drainage*

Danger! Cool, sexy, imported products may not work.

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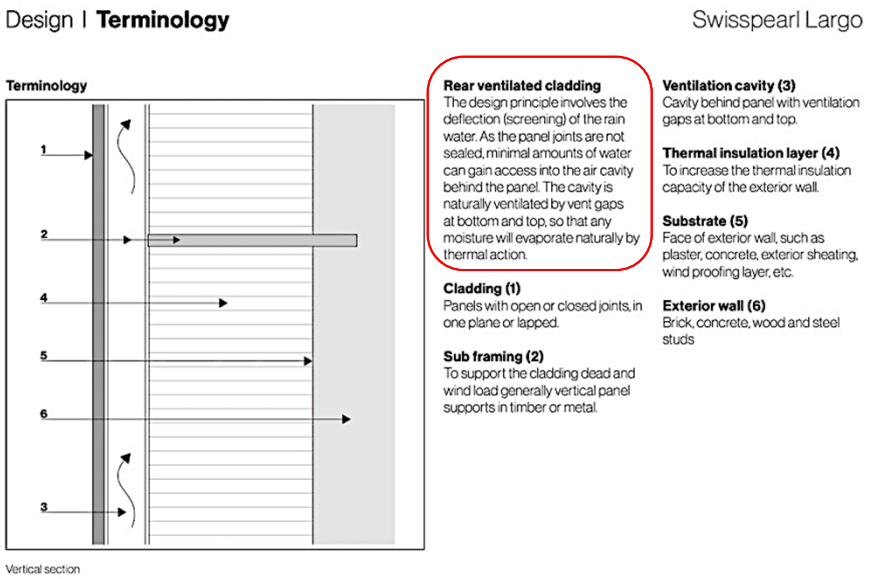

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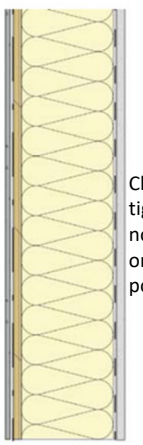
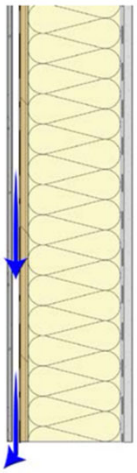
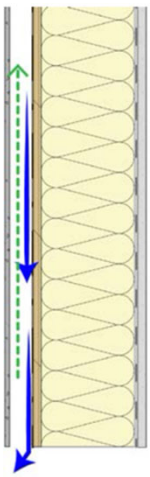
Air gap size vs function



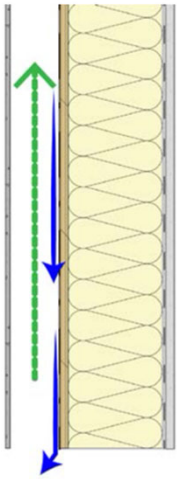
Cladding tight to WRB, no drainage or airflow possible



Small gaps and discontinuities (no contact) allows drainage but little airflow



Moderate gap (1/2") allows drainage, decent airflow and stops drop bridging



Full gap (>3/4") allows drainage, full airflow and stops drop bridging
Fire propagation becomes a concern >1"

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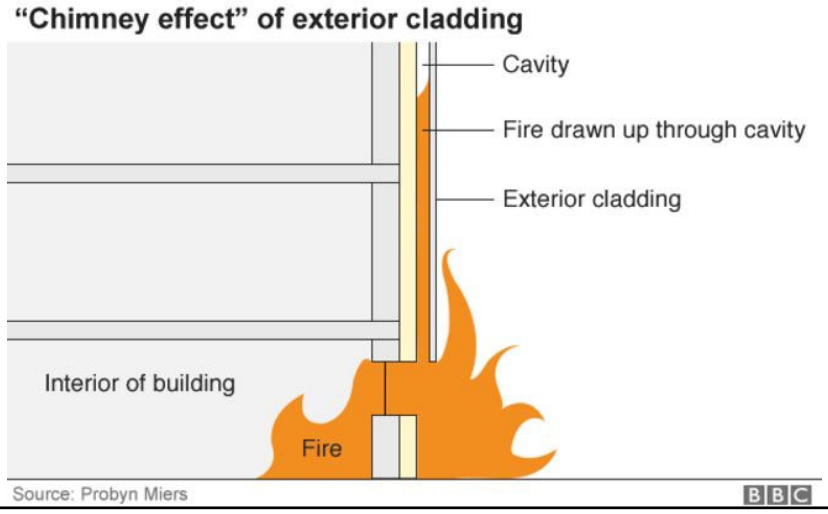
Why not bigger is better?

- Fire, rodents, birds. To avoid… gaps of under 2” are preferred



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Discussion + Questions

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The Holy Grail

PRESSURE EQUALIZATION

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Pressure Equalized Rainscreens

- Popularized by curtainwall industry
- In a time when *neither* air barriers or drainage where part of all walls !

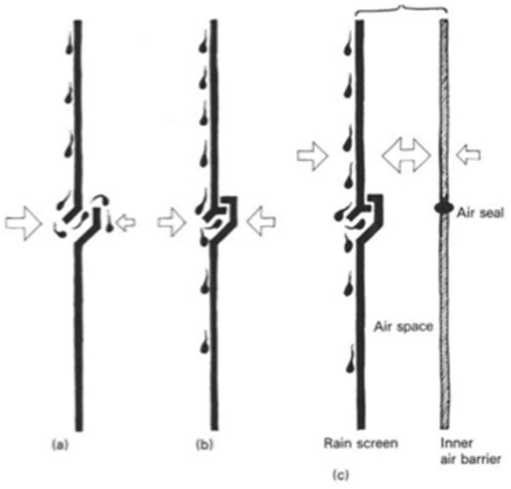

Fig. 5 Essential features of the rain screen and pressure-equalized wall construction (based on AAMA, 1971).

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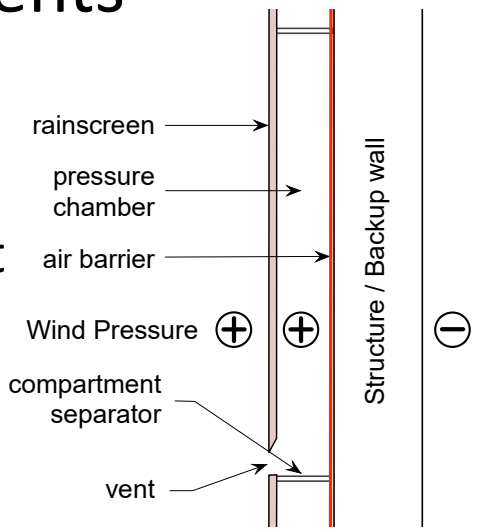
PER components

- No drainage

1. Rainscreen cladding
2. Air chamber/compartment
3. Air barrier
4. Vent
5. Compartment seperators



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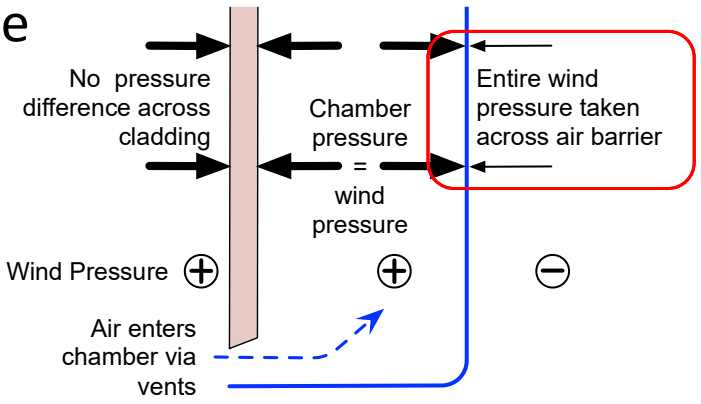
Pressure Equalized Theory

- Theory: no air pressure across cladding = no rain leakage
- Locate a single vent per compartment



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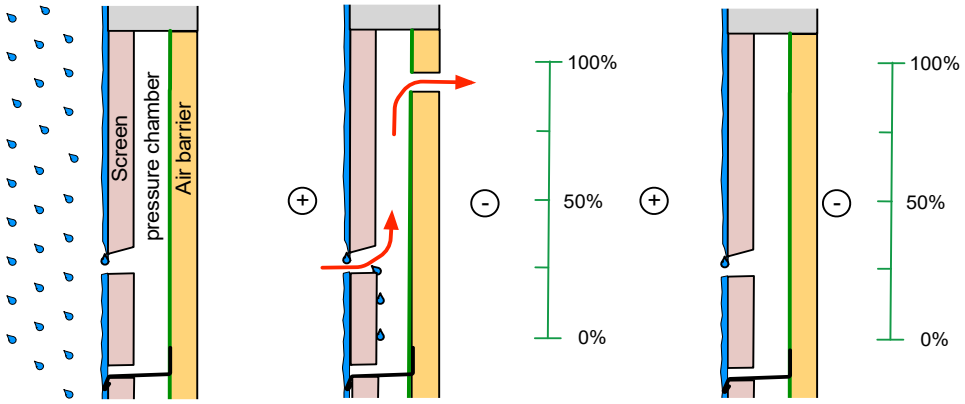
Theory



Rainfall on wall
Water flows past opening

Wind pressures drive airflow & water through opening

A perfect air barrer results in no airflow or pressure across cladding

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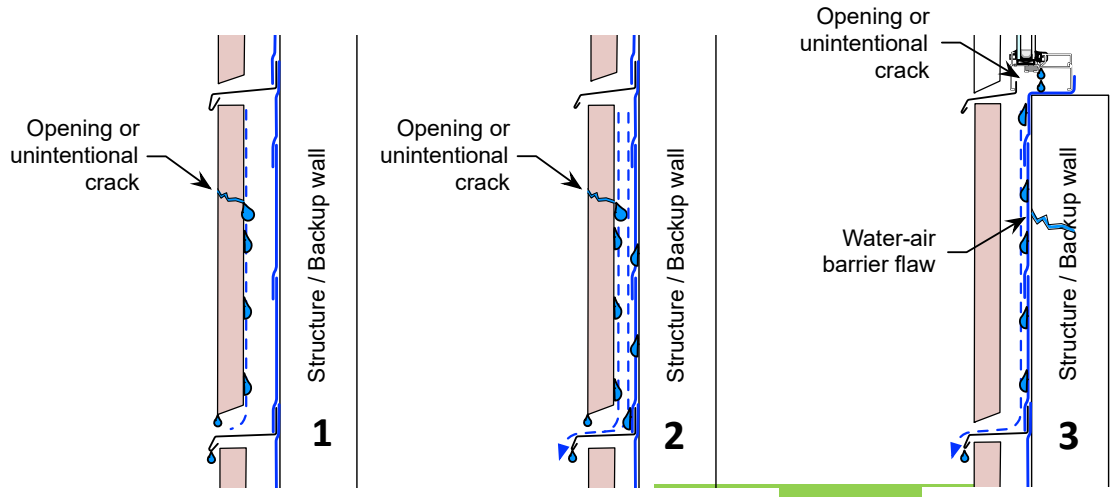
But cladding leaks anyway ….



Gravity remains the biggest

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Pressure Equalization Theory

- Curtainwall mullion

"Interior seal … does not see water"

- Unless it does, e.g. surface tension, horizontal mullion, sloped curtainwall

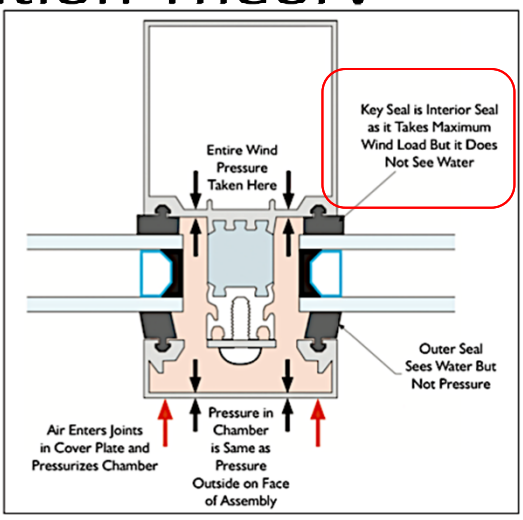

Figure 6: More magic: Drainage occurs at mullions as well. Cover cap is leaky to air allowing air entry to pressure moderate airspace.

Lstiburek,J. *Drainage, Holes and Moderation*. 2008.

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Summary of PE

- PE only stops air-pressure driven leaks
- Gravity leaks occur anyway
  - So you need a good WRB and flashing
- Today, we *often combine* AB and WRB, thus PE means all air pressure is across the WRB
- Dynamic pressure variations are a challenge…

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COMPARTMENTALIZATION

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Compartmentalization

- Wind is not *spatially* uniform
  - Pressure at corners can be very different than middle of building
  - And pressures vary second by second
- Air "chamber" is divided to reduce pressure variation

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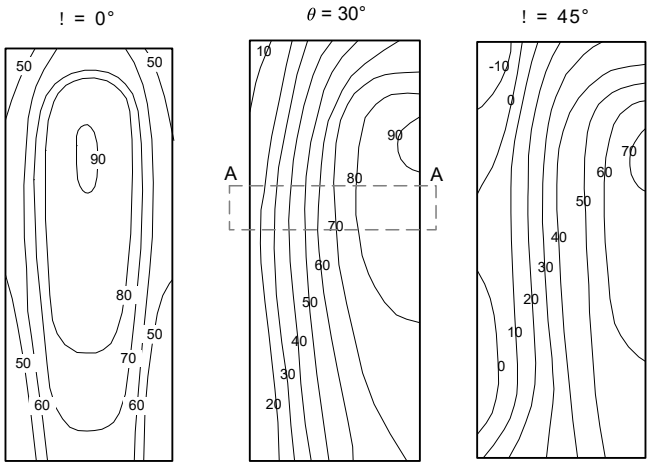
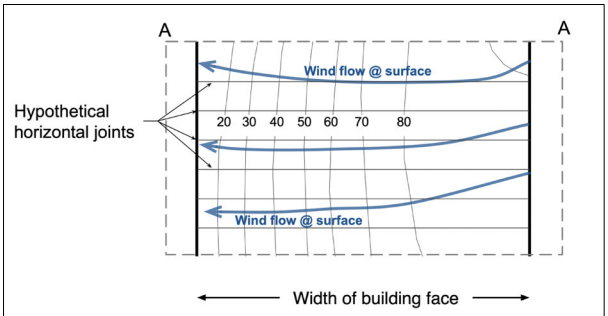
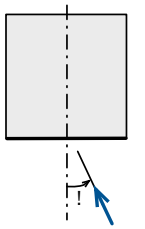
Spatial Gradients



Wind pressure variation over building face as percentage of stagnation pressure and resulting air flow (adapted from ASHRAE 2017)



Detail Elevation (A-A) of pressure variation, resulting airflow, and impact on horizontal joints of enclosure (for θ = 30°)



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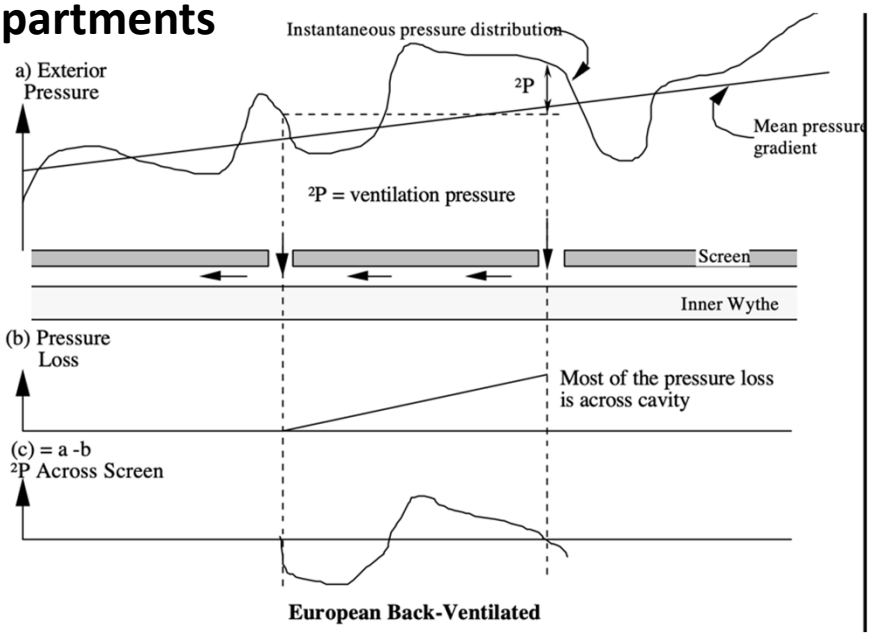
No compartments



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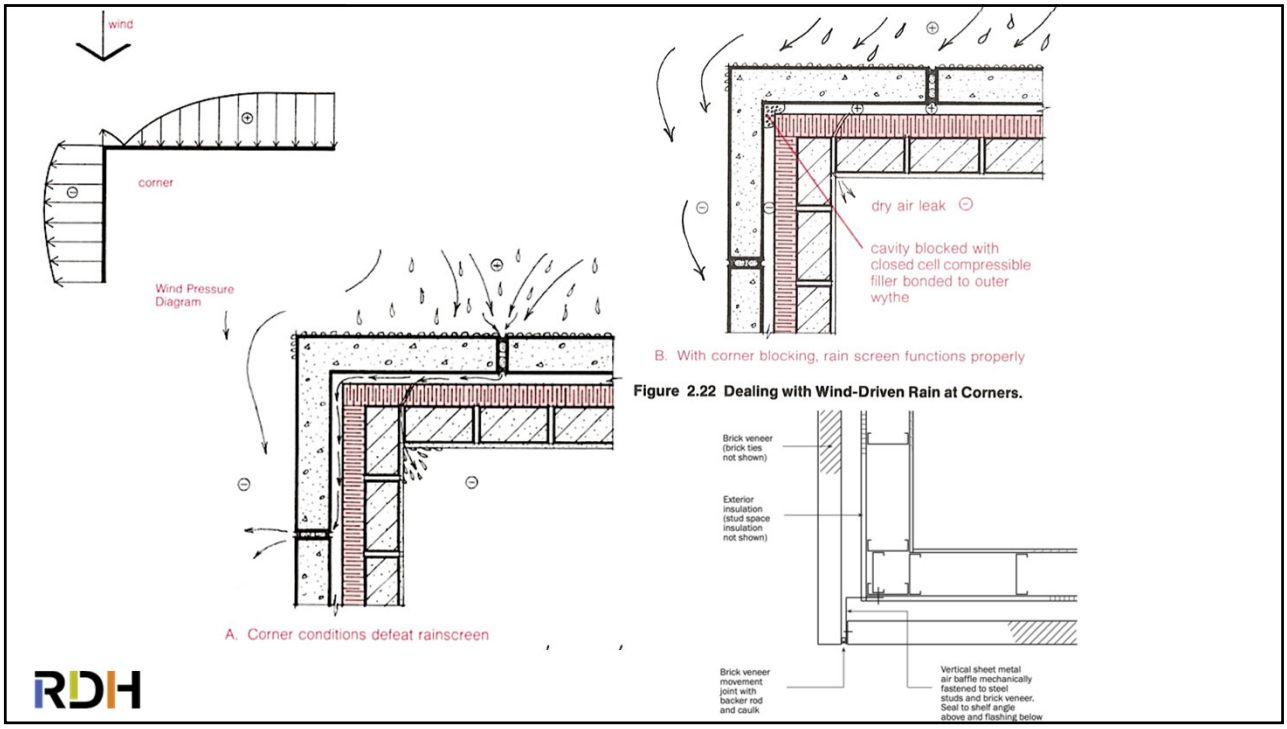

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SO, WHAT IS A RAINSCREEN?

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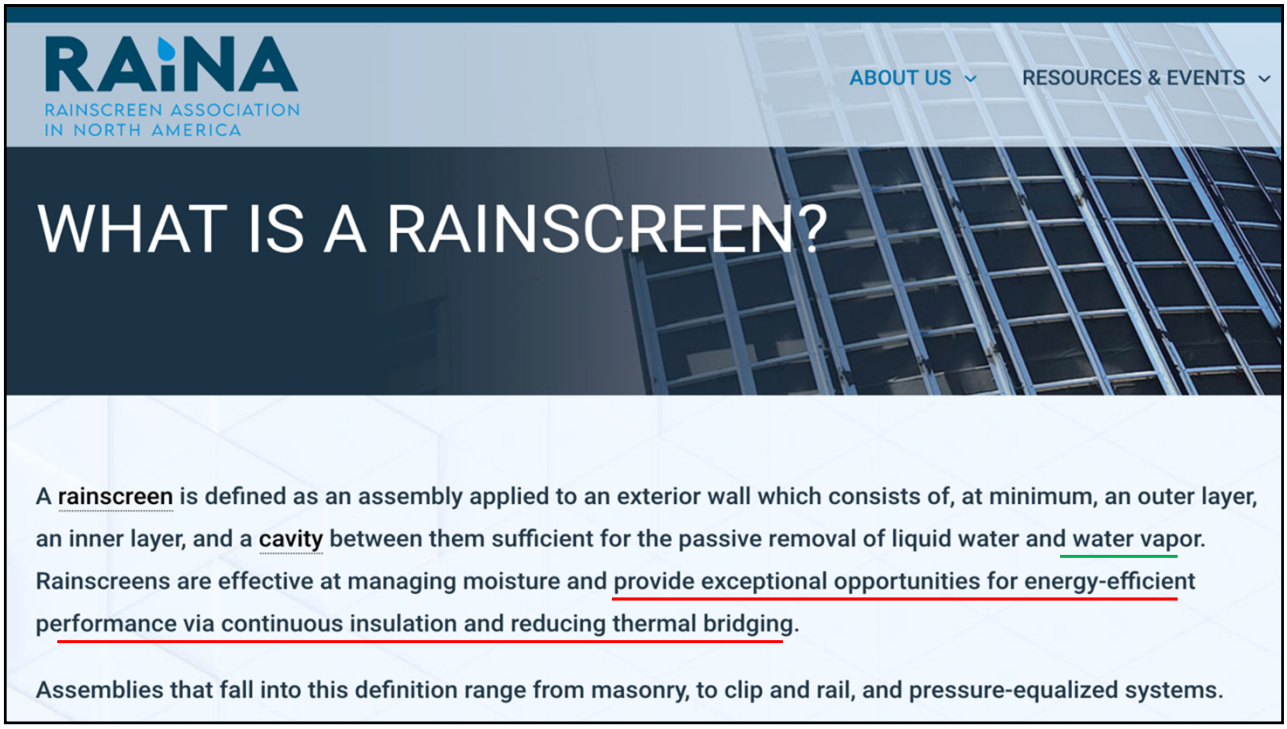

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Rainscreen Association

- Recently formed
- Working on terminology and
- Performance standards

RAiNA

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From www.rainscreenassociation.org

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Rainscreen

- Rainscreen is **above all**, a drained system
- Ventilation can be added
  - provides benefit for some, not all, walls
- Pressure-equalization can be added
  - Provides modest improvement to rain control
  - Simple venting & airtightness provides most rain control improvements over drainage

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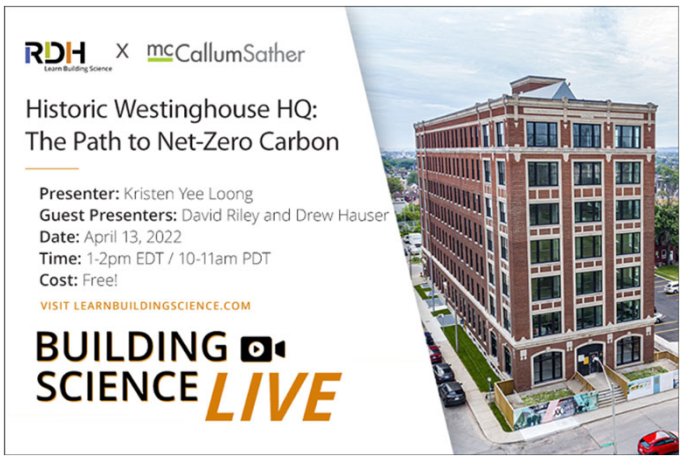

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