Central Artery/Tunnel Project - Ventilation Building No. 7 by TAMS/Wallace/Floyd Associates/Stull Associates

Rainscreen Cladding Systems

Richard Keleher

Presentation Agenda

Principles

History
- Historical projects
- Local projects

Video

Applications
- Curtain wall details
- Other Details
  - What ***not*** to do
    - The window problem
    - Window details
    - Curtain wall details
- A case study project

Summary

Presenter:

Founder and Chair, Building Enclosure Council, Boston

Chair, AIA Building Science Knowledge Community Advisory Group

Board Member, BETEC
(Building Enclosure Technology & Environment Council)

Technical Quality & Building Enclosure Consultant

Take-Away Messages

1. Cavity walls, or two-stage weather-tightening as it is called in Europe, are the only way to obtain durable, dependable weather-tightness.

2. The importance of the air barrier to prevention of:
   - Water penetration (performance of rainscreens)
   - Mold, mildew, rot, and corrosion.

   Canadians: "cherchez le trou," or "find the hole."

3. The term "rainscreen" has been bandied-about of late; hopefully this workshop will clarify what a rainscreen is and how it may be used to advantage on your projects.

Sealants

Causes of Deterioration

- Ozone
- Sunlight
- Ultraviolet radiation
- Rain
- Snow
- Temperature extremes
- Differential thermal movement

Installation Requirements

- Proper surface preparation
- Compatible sealant and
- substrate
- Proper backer rod type and position
- Properly tooled joints

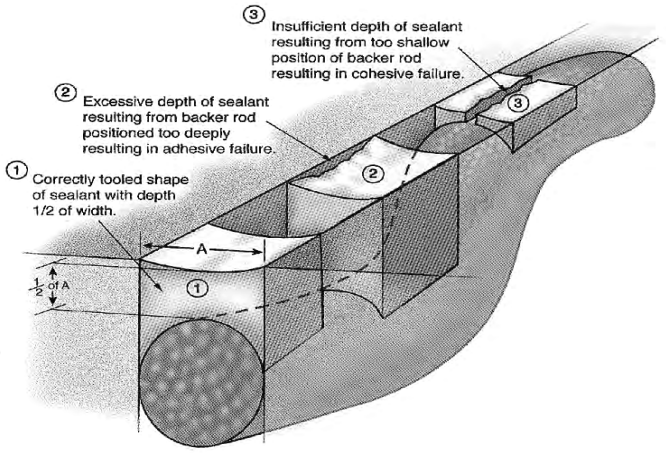
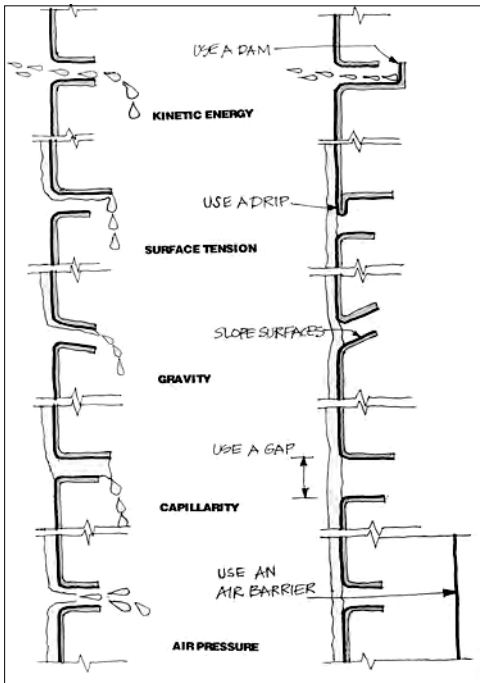
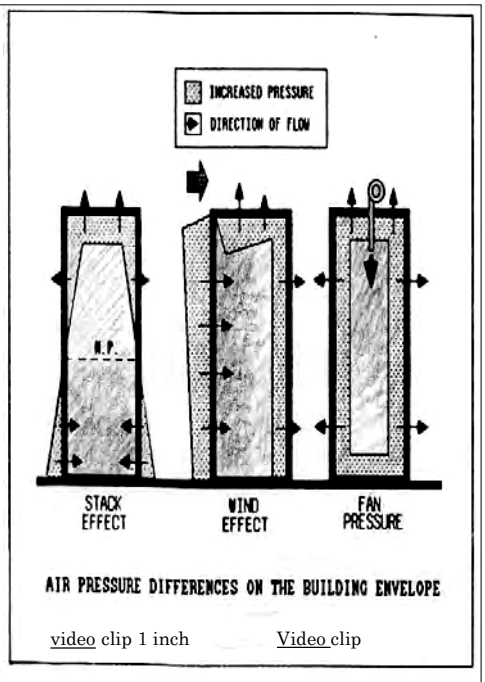


Figure 2: Shows need for correct positioning and sizing of backer rod and correct shaping of sealant.

Sealant Geometry Requirements for Proper Performance



Forces Driving Air Through the Wall



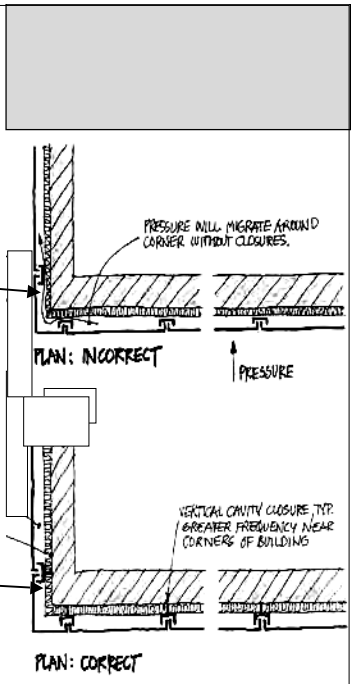
video clip 1 inch Video clip

Air Pressure Differences

Pressures at Corners

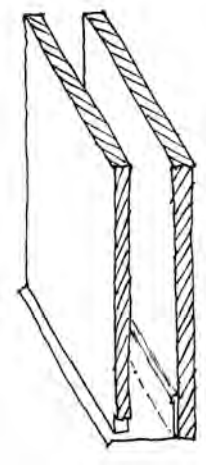
Air movement
(not pressure-equalized)

No air movement
(possibly pressure-equalized)

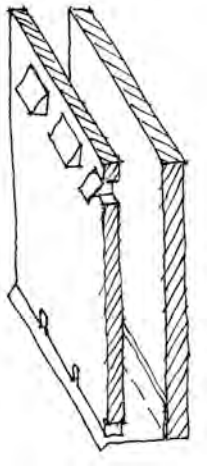


Types of Rainscreens

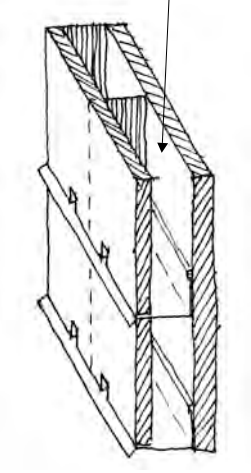
Note: block off excessive cavity size



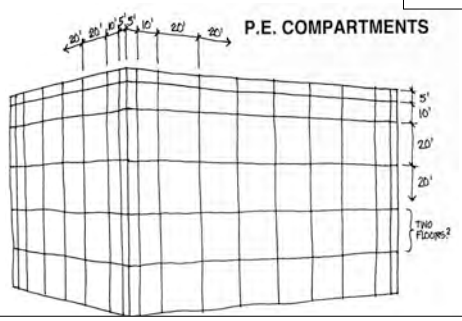
Weeped and Vented



Drained and Vented

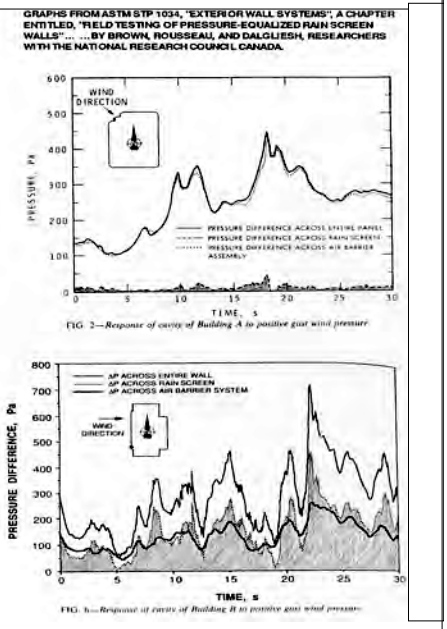


Pressure-Equalized



Pressure-Equalization Compartment Sizes

Asymmetrical venting: locate inlets toward center of façade to ensure complete pressure-equalization



Pressure-Equalized (above)
Non-Pressure-Equalized (below)

Principles of Pressure Equalization

- Rapid pressure-equalization and cavity-closers
- Air barrier versus vapor barrier
- Adequate venting area

Air Barrier Design Requirements

- Continuous
- Secure and rigid
- Air impermeable
- Durable
- A critical element for pressure-equalization

The Four Planes

(from outside to inside)

1. The Rainscreen
2. The Drainage Plane
3. The Air Barrier
4. The Vapor Barrier

See next slide for required venting area.

Rules of Thumb

(with rigid air barriers and non-gusting winds)

The air barrier should have at least 10x the vapor permeability of the vapor barrier.

Leakage of the air barrier should not exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 inches of water (1.56 psf)

Vent Area

The greater of:

Static loads:

Vent area ≥ 5 x ELA of the air barrier
plus 10 x ELA of any corner seals
plus 1 x ELA of intermediate compartment seals

ELA = Effective Leakage Area

Dynamic loads:

Vent area (m^2) ≥ volume of compartment (m^3)/ 50m

Note: The Effective Vent Area is limited to by the narrowest part of the venting path.

Examples of Air Barriers

and insulation

Advantages of Rainscreens

Sealants not required

The air barrier is not subject to:

- Thermal movement
- Heavy wetting
- Ultraviolet radiation

Less condensation; cavity breathes and dries

Insulation on outer face of inner leaf; not bridged by structure

Complicated panel intersections are possible

Outer panel can be purely esthetic; freedom from need to seal joints allows for design flexibility

Concerns About Rainscreens

The omission of sealant isn't a panacea.

Lack of clarity about the responsibility for water penetration and lack of a national standard to prove performance.

There are many cases where the metal panel manufacturer/ installer thinks that the air/vapor barrier/ drainage plane installer is going to take care of any water that gets past the metal panels.

Actually, if the joints in the rainscreen are left unsealed, they can allow large amounts of water into the cavity, where they will be on an air barrier (drainage plane) which now has the full force of the wind acting on it.

Fortunately, there is progress on the latter. AAMA has a Task Group, of which I am a member, working on such a standard.

Summary

Essentials

An interior air-tight seal (the air barrier)

An air chamber or vented cavity

A rain barrier, properly detailed to resist the Forces

Concerns

The depth of knowledge of:
- The A/E
- The Contractor and Subs

Lack of national standards

Inspection and testing
- Mockups
- Quality control testing
- Inspection
- Post-construction testing

Take-away Message

You cannot reliably protect your building from water intrusion without using what the Europeans call "two-stage weather-tightening" and the Canadians call "rainscreen." The Canadians prefer to use the pressure-equalized variation of this wall construction, which they call "PERSIST," or the Pressure-Equalized Rainscreen Insulated Structure Technique."

History of Rainscreen Cladding

Historical Sequence:

Vapor Issues

- **Historically**, (several centuries ago and before) large-scale walls were mass walls whose thermal mass delayed transmission of temperature, absorbed water, and then dried-out (or in).
- **To save energy**, we added insulation which, in certain situations led to severe vapor deposition.
- **To prevent this**, we added vapor barriers, but in so doing, prevented the drying of walls inward.
- **And often we still had air leakage**, which transported vapor behind the vapor barrier.
- Now, finally, we are addressing **hygrothermal** issues in wall design , through the use of WUFI and other resources.

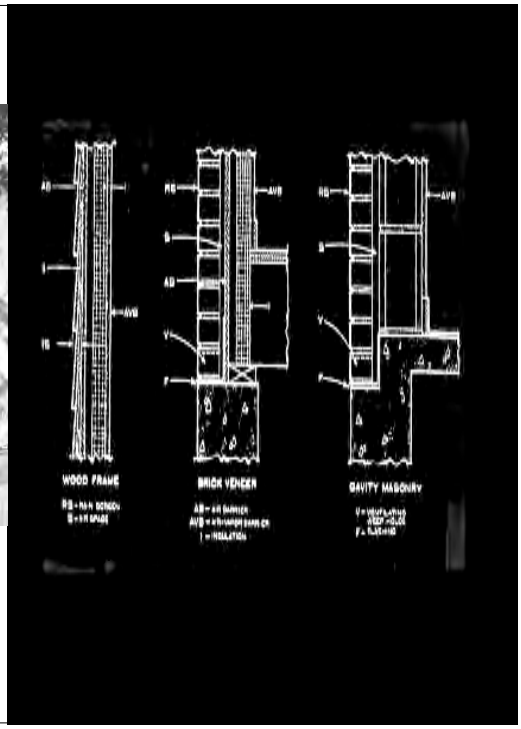
Historical Sequence:

Water Issues

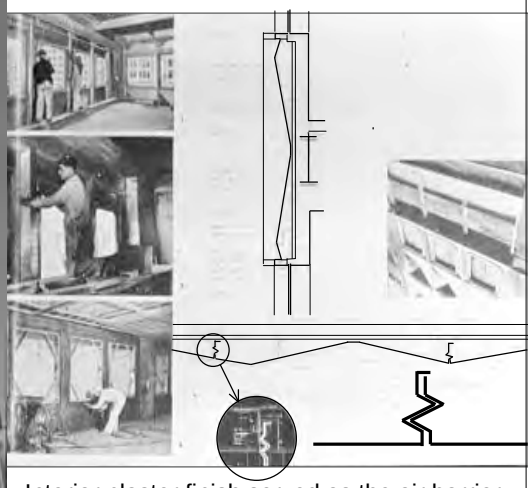
- **Skeletal frames** led to the need for **sealants**, to seal the discontinuous elements, which could not absorb the quantity of moisture that the monolithic bearing wall systems could.
- **Difficulty of achieving an adequate and durable seal**, even with high performance sealants. This defect was not realized for some time
- **Need for a predictable and durable method of construction** that was not subject to the need for perfect execution and that would not be damaged by ultraviolet light.
- **Development of the drained cavity wall** (back-ventilated and drained rainscreen) and **then the pressure equalized rainscreen**.

Log House, Norway – centuries old "open-jointed barn" technique

Sparrow House, Plymouth, MA, 1630



After early work by the Scandinavians and Canadians (Kirby Garden et. al. at the National Research Council/Canada – "The Rainscreen Principle" published in 1965) and the adoption by AAMA of the rainscreen principle for curtain walls shortly thereafter, the idea lay fallow except for an intuitive leap of faith by Harrison and Abramovitz in their design of the Alcoa Building in 1971.



Interior plaster finish served as the air barrier. Tested in 1971 by AAMA - perfectly weather-tight.

Alcoa Building Pittsburg, PA, 1952 - Harrison & Abramovitz

Aluminum Plate Rainscreen

(pressure-equalized) by Vicwest Steel

National Aviation Museum Ottawa, Ontario, 1986 Architect: Parkins & Associates

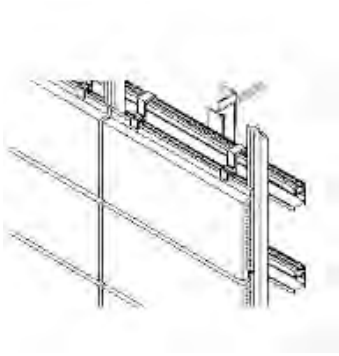
Royal Bank of Commerce Edmonton, Alberta, 1991

Xerox Corporation Mississauga, Ontario

Calgary Oval Olympic Arena Roof

Terra Cotta Rainscreen

(back-ventilated and drained) by Shildan (MBK, Terreal)



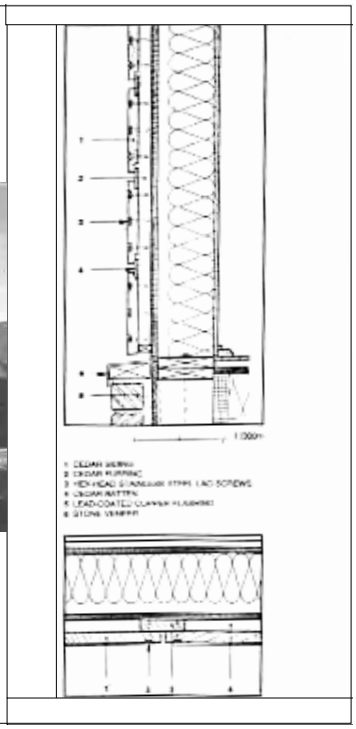
System Diagram

East Boston Savings Bank

Wood Siding Rainscreen

(back-ventilated and drained)

Carwill House Vermont William Pederson



Recently Completed Local Projects Utilizing the Rainscreen Principle

(also, every curtain wall)

Federal Reserve Bank of Boston
1975 **The Stubbins Associates**

Double-mullion unitized curtain wall with 1/8” aluminum plate facing, clear anodized finish

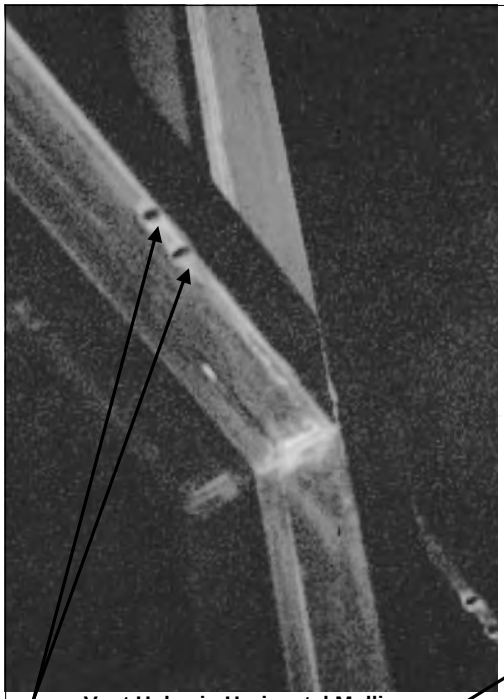
125 High Street Jung/Brannen Assoc.

Dana-Farber Cancer Institute Smith Research Labs Shepley Bulfinch Richardson and Abbott

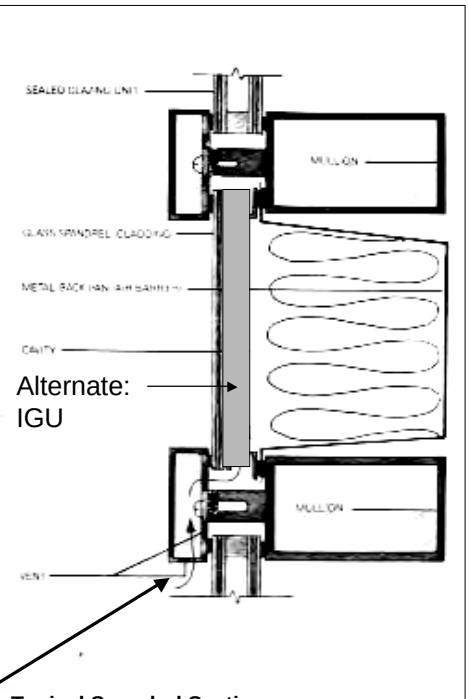
53 State Street WZMH Habib

53 State Street as an example of a typical pressure-equalized curtain wall system

Details on next slide



Vent Holes in Horizontal Mullion

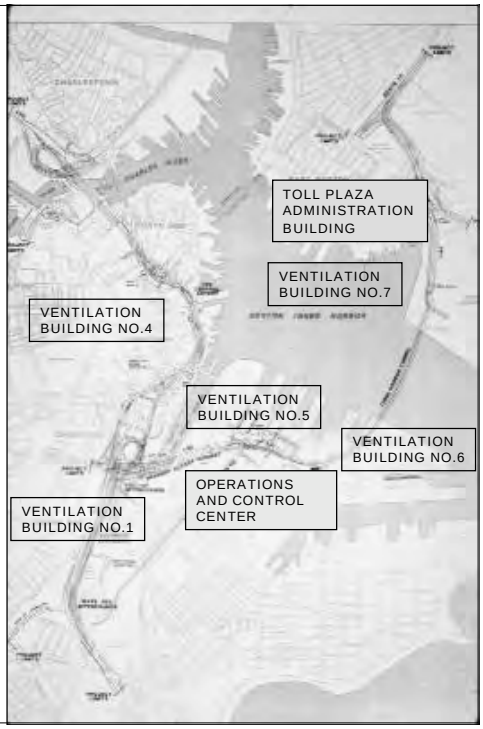


Typical Spandrel Section

Amgen

back-ventilated and drained rainscreen

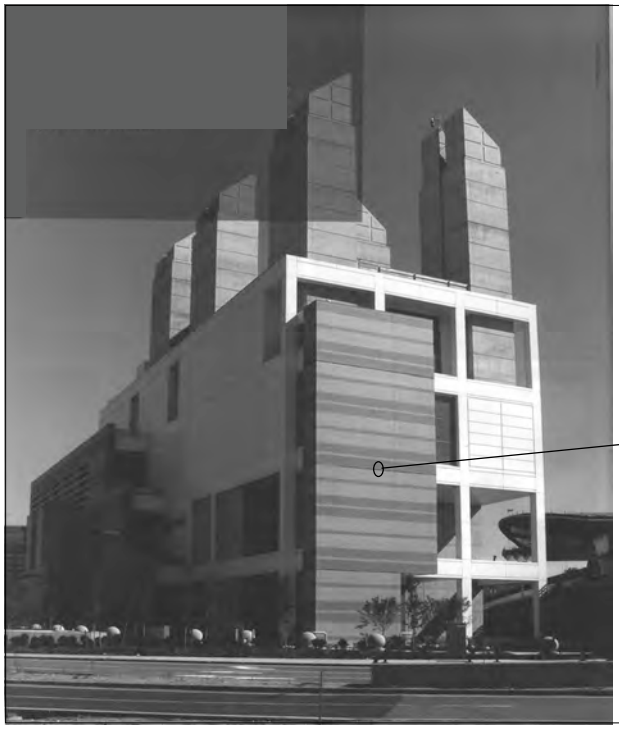
Central Artery/Tunnel Buildings Utilizing the Rainscreen Principle



BigDig Administration Building
Wallace, Floyd, Associates / Elkus Manfredi

BigDig Fire & Rescue Station
Wallace, Floyd, Associates / Elkus Manfredi

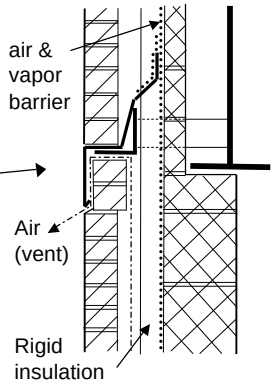
This is the Case Study Building



Ventilation Building No. 5

Wallace Floyd Design Group
CWA / MJA Joint Venture

Back-ventilated rainscreen



Ventilation Building No. 6 **Wallace Floyd Design Group / Barrientos Associates**

A message from our sponsor

I am available for peer reviews and technical consulting in the following phases:

- General: office-wide drafting standards manual
- Schematic Design
- Design Development
- Construction Documents
- Construction Administration
- Best practices for high-performance sustainable design

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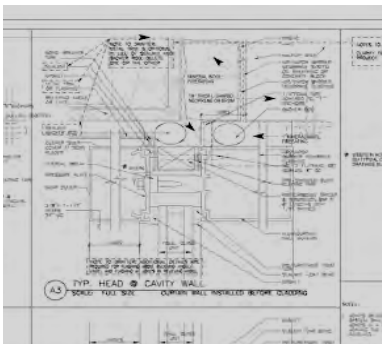
www.rkeleher.com

Schematic Design

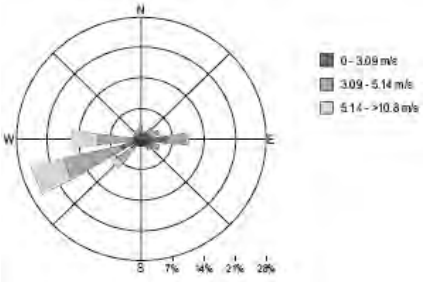
- Recommended Systems
  - Uniformat Outline Specifications for building enclosure
  - Constructability, sequencing and relative costs
  - Typical large-scale details that are actually correct! less zooming



- Review SD Set

Schematic Design continued

- Climate Data Analysis
  - Comparisons to MA weather
  - Comparisons to the comfort zone
  - Wind roses



Atlanta

The tables below display average monthly climate and weather indicators in Atlanta, Georgia.

Temperature by: Fahrenheit / Celsius

Atlanta Temperature	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temperature	41.0	44.8	53.5	61.5	69.2	76.0	78.8	78.1	72.7	62.3	53.1	44.5	61.3
Avg. Max Temperature	50.4	55.0	64.3	72.7	79.6	85.8	88.0	87.1	81.8	72.7	63.4	54.0	71.2
Avg. Min Temperature	31.5	34.5	42.5	50.2	58.7	66.2	69.5	69.0	63.5	51.9	42.8	35.0	51.3
Days with Max Temp of 90 F or Higher	0.0	0.0	0.0	< 0.5	1.0	8.0	13.0	10.0	3.0	0.0	0.0	0.0	36.0
Days with Min Temp Below Freezing	16.0	12.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	< 0.5	5.0	12.0	49.0

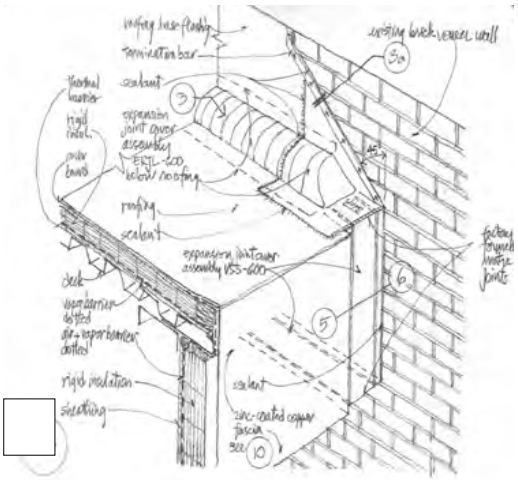
Atlanta Heating and Cooling	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Heating Degree Days	744	566	365	138	27.0	0.0	0.0	0.0	10.0	138	367	636	2991
Cooling Degree Days	0.0	0.0	8.0	33.0	157	330	428	406	241	54.0	10.0	0.0	1667

Atlanta Precipitation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (inches)	4.8	4.8	5.8	4.3	4.3	3.8	5.0	3.7	3.4	3.0	3.9	4.3	50.8
Days with Precipitation 0.01 inch or More	12.0	10.0	11.0	9.0	9.0	10.0	12.0	10.0	8.0	7.0	9.0	10.0	116
Monthly Snowfall (inches)	0.9	0.5	0.4	< 0.05	0.0	0.0	0.0	0.0	0.0	< 0.05	0.0	0.2	2.0

Other Atlanta Weather Indicators	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Wind Speed	10.4	10.7	10.8	10.1	8.7	8.1	7.7	7.3	8.0	8.5	9.1	9.8	9.1
Clear Days	8.0	8.0	9.0	10.0	9.0	8.0	6.0	7.0	10.0	14.0	12.0	9.0	110
Partly Cloudy Days	9.0	6.0	8.0	8.0	11.0	12.0	13.0	13.0	10.0	7.0	6.0	6.0	107
Cloudy Days	16.0	14.0	15.0	12.0	11.0	10.0	12.0	10.0	10.0	10.0	12.0	15.0	149

Design Development

- Architectural Sheet List
- Cartoon Set Covey
- Typical Wall Sections
- Project-specific Typical Details
- Complex Details (e.g. seismic joints)



- Review DD Set

Construction Documents, CA, etc.

Construction Documents: review sets for:

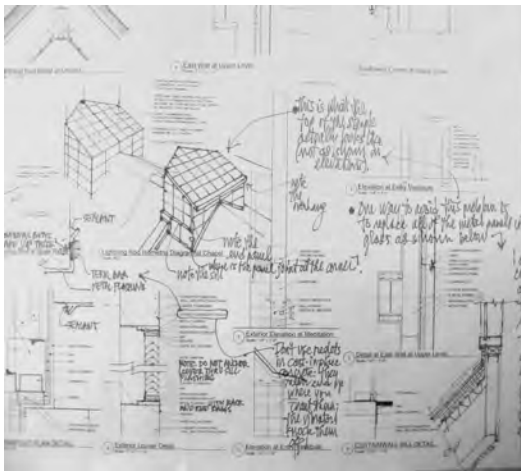
- Coordination of drawings
- Proper detailing of the building enclosure

Construction Administration:

- Attend and advise on mock-up and field testing
- Resolution of unforeseen problems

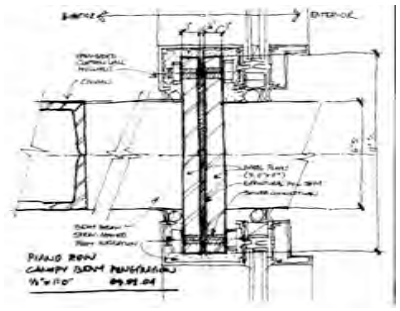
General:

- Develop office-wide drafting standards manual



Construction Administration

- Attend and advise on mock-up and field testing
- Studies of complex conditions
- Resolution of unforeseen problems



General:

- Develop office-wide drafting standards manual

State-of-the-Art Building Enclosures

- There is much that we have done, but we have much more to go!
- Air barriers will be adopted nationally. Issues:
  - Implementation.
  - Air pressures.
    - Balancing.
    - Leaks/condensation.
  - Over-design of mechanical systems.
- Architects need to take the initiative to save their practices (and their shirts)!

Conclusion

Assistance in best practices for:

- High-performance
- Sustainabililty
- Durability
- Creativity!

Herb Garden on Vancouver's Fairmount Waterfront Hotel (courtesy David Walker)

Ventilation Building No.7 TAMS/Wallace Floyd Design Group / Stull & Lee

Video Provided by Centria