Pressure Moderated Precast Rainscreen
A Case Study

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What is Rainscreen Precast Curtainwall?
Of great theoretical and practical importance…

translation:

I found it interesting…

- Werner Gumpertz
Curtainwall: “A non load-bearing exterior wall”

Precast: “Concrete that is cast in a form”

Rainscreen: ???
Wall System

- Joints
- Elements

Imperfect Barrier
- Mass or Storage Types
  - Less mass and lower permeability
  - More mass and more permeability
- Cavity
  - Ventilated
  - Vented
- Unvented
  - Pressure moderated
  - Ventilated and pressure moderated

Perfect Barrier
- Drained or Screened Types
  - No Cavity
- Perfect Barrier Types
  - Face Sealed
  - Concealed Barrier

From “Building Science for Building Enclosures” - Straube, Burnett
Case Study - Background Questions

→ How to practically construct a rainscreen precast wall assembly?

→ How much pressure equalization occurs on a rainscreen cladding assembly?

→ Effective vs. Designed Air Barrier – where is it really?
32 Story Multi-Unit Residential Building
Concrete Framed, Post-Tension Slabs
Football Shaped Plan
Glazing: Aluminum Window Wall
Opaque Cladding: Precast Concrete curtainwall
Cladding Design Philosophy:
- Exterior Insulated
- Self-Adhered Weather Barrier
- Rainscreen
Background – The Primary Team

- **Developer (Williams & Dame, Gerding/Edlan)**
  - Proactive
  - Risk-averse
  - Performance driven

- **Architect (GBD Architects)**
  - Sophisticated level of experience
  - Exterior insulated rainscreen was common practice
  - Performance driven, Risk-averse

- **Contractor (Hoffman Construction Company)**
  - Engaged during pre-design
  - Proactive, Sophisticated
  - Performance Driven, Risk-averse
Others engaged during early design

- Enclosure Consultant
- Structural Engineer
- Mechanical Engineer
- Structural Detailer (Precast)
- Wall Constructor Sub-Contractor
During design – question arose:
  How much of the lateral wind load needs to be addressed by the backup wall system?
Pressure Equalized Rainscreen

- Cladding
- Air Barrier Membrane
- Air Pressure Gradient
Pressure Equalized Rainscreen

Cladding

Air Barrier Membrane

Air Pressure Gradient
Wall System

Joints

Elements

Imperfect Barrier

Perfect Barrier

Mass or Storage Types

Drained\(^2\) or Screened Types

Perfect Barrier Types

Cavity\(^3\)

No Cavity

Face Sealed

Concealed Barrier

Ventilated\(^4\)

Vented\(^5\)

Unvented

Pressure moderated\(^6\)

Ventilated and pressure moderated

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From “Building Science for Building Enclosures”
- Straube, Burnett
Theory and Research

- Straube, Dr. J.F., *Moisture Control and Enclosure Wall Systems*, Univ. of Waterloo, 1998
- Dr. Eric Burnett & Dr. John Straube – various papers
- Investigations directed by Jacques Rousseau for CMHC
“...it is well accepted that the cladding does carry a significant percentage of the wind load. Nevertheless, the air barrier system and its structural supports must still be designed for the full wind load.”

- Straube, John F.
Commonly Accepted Practice

Influencing Factors:

- Wind characteristics
- Building form
- Ventilation area and Chamber volume
- Air barrier performance
- Wall Rigidity
Objectives & Scope

→ **OBJECTIVE**: Develop a constructible rainscreen precast cladding system.

→ **OBJECTIVE**: Confirm commonly accepted practice for lateral wind load at air barrier. Add to body of knowledge.

→ **SCOPE**: Measure in-service pressures at cladding and air barrier planes
We accepted that:

- Data collection is limited at two discreet points and does not ‘see’ effects of spatial non-uniformity

- Ventilation area is small (about .1% of chamber area)

- Primary project objective is to design a well-performing drained cavity assembly without assumption of pressure moderation benefits

- Primary research interest is the overall relative pressure values at cladding and air barrier, rather than the moderation response time
Note on Compartmentalization
Original design concept anticipated an “Inside to Outside” construction sequence
Project Constructability – Rainscreen Precast
Project Constructability – Rainscreen Precast
Project Constructability – Rainscreen Precast
Project Constructability – Rainscreen Precast
Precast detailing, panels sizes, and other constructability issues required more traditional “Outside to Inside” sequence.
- Result required a pre-fabricated, panelized, interior wall assembly.
- Precast attachment utilized bolted connections to minimize welding near self-adhered membranes.
Assembly
6 TYP. PRECAST PANEL - SLAB EDGE
Insert Build Slides of Assembly
Insert Build Slides of Assembly
Insert Build Slides of Assembly
Water Control: Continuity of the water control layer to the interior is provided by the SAM over each interior wall panel. At the sill of each panel, there is a back-seal connecting the panel to the SAM flashing over the deflection head below, and continuing to the next panel below. A silicone sealant joint and backer rod is installed at vertical panel-to-panel joints.

The exterior of the precast panels and exterior silicone sealant joints provide water shedding function.

Air Control: Continuity of the air control layer is provided by the same materials as the water control layer above, with the addition of a silicone sheet connector between the interior vertical leg of the deflection track and the interior vertical leg of the panel wall framing. This additional material is necessary to accommodate deflection at the panel head in an airtight manner.

Thermal Control: XPS insulation is installed on the outside face of the panelized walls. Continuity at the slab edge is provided by additional XPS pieces installed at the slab edge and over the through-wall flashing.

Vapor Control: The SAM serves as a vapor control membrane.
Shedding
Air

Seal @ Back Angle

DOW 123
Shedding

Water & Vapor

Air

Seal @ Back Angle

DOW 123

Thermal
Instrumentation and Methodology
Data Analysis

Typical results are shown…

translation:

The best results are shown…

- Werner Gumpertz
Wind speeds were very low throughout the duration of the study.

Wind direction was very sporadic and varied. Localized architecture resulted in significant "glancing" angle wind events (far from perpendicular).

Much of the wind produced negative pressures.

Wireless equipment made data collection at short time intervals difficult.

Practical aspects of research on a "live" building made data collection difficult. Construction schedule, sequencing of work, building closeout, etc., regularly interfered with research.
It is clear that much additional work will be required before [we have] a complete understanding…

translation:

This is a miserable subject and any more work done in it will be by someone else…

- Werner Gumpertz
At low pressures (<10Pa), equalization is fairly close to 100%

There is a time delay for cavity pressure equalization, but is not significant for purposes of this effort

Cavity pressures are “dampened” compared to cladding pressures

At higher pressures (>40Pa), equalization varies, but can be limited to 40% of short duration gust pressures
As other research has shown, pressures within the cavity are difficult to predict, are highly dependant upon the building cladding design, orientation, degree of ventilation, etc.

Design should anticipate full lateral wind pressures to both the backup wall assemblies and the screen.
Final Thoughts on Design and Monitoring…

- Panelized interior wall assemblies require significant attention to air seals, constructability (blind), and other. Not a design that should be taken on lightly.

- Monitoring during “live” construction was complicated due to finishing schedules, etc. This study was not anticipated in advance, and suffered scheduling complications as a result.

- Wireless transmission monitoring was problematic and difficult to implement effectively, which limited our time for data collection.
Thanks are due to Natalie William Portals (University of Waterloo) for assistance with the experiment and to Graham Finch (RDH) for valuable discussions.

translation:

Portals did the work for me and Finch explained what it meant. If you have any questions, see them – not me!

- Werner Gumpertz

Special thank you to SMT Research for many volunteer hours and travel time assisting with equipment setup and operation.
Thank you

→ Questions?