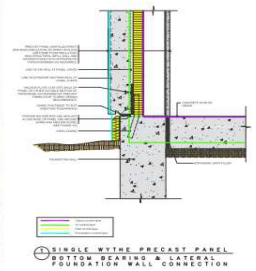
Architectural Precast Concrete Walls



Best Practice Guide

Presented by:
Malcolm Hachborn, President, M. E. Hachborn Engineering
(Precast Concrete Engineering)

Overview

- Introduction
- Definitions
- Manufacturing
- Performance
- Detailing
- Construction

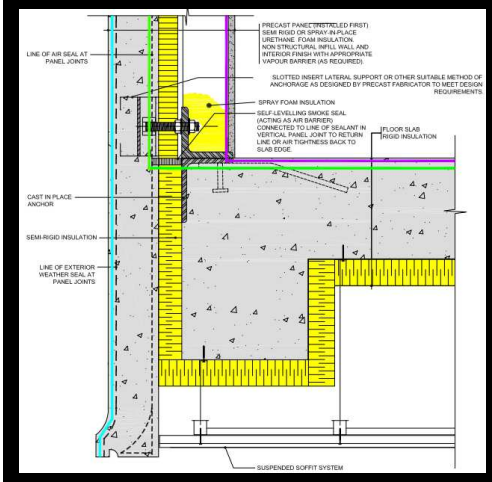
1.0 Introduction

- Background
- Purpose
- CPCI
- Other Publications

1.1 Background

- In Use Since 1920s
- Popular Since 1950s
- Hauling Equipment
- Crane Capacity
- Broadened Product Range
- Material Innovations

1.2 Purpose



- Review Design and Construction Process
- Outline Building Science Fundamentals
- Look at Critical Considerations
- Illustrate Examples of Good Detailing

1.3 Who is CPCI

CPCI Represents

- Body of Knowledge in Canada
- Represent 85% of Precast Produced in Canada

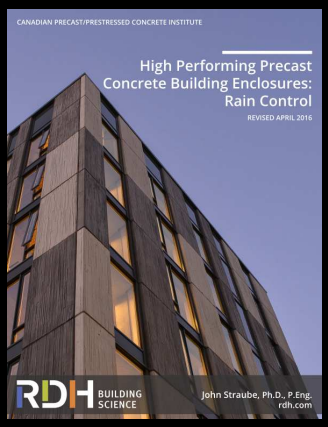
CPCI does

- Funds Precast Research
- Creates Precast Publications

CPCI Certification

- Most Stringent of CSA and PCI
- 2 Day Audits by Engineers
- Name has Changed to CPCQA as of January 1, 2018

1.4 Publications



- **Best Practice Guide**

- **Rain Control Guide**
- **Maintenance and Inspection Manual**
- **Thermal Performance Guide**

2.0 Definitions

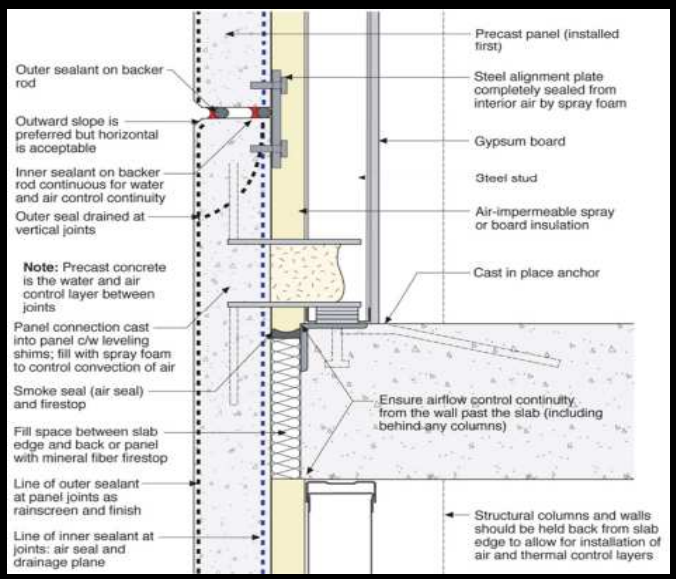
- Panel Types
- Panel Configurations
- Wall Panel Layout – Jointing
- Aesthetics – Colours, Textures, Finishes

2.1 Panel Types

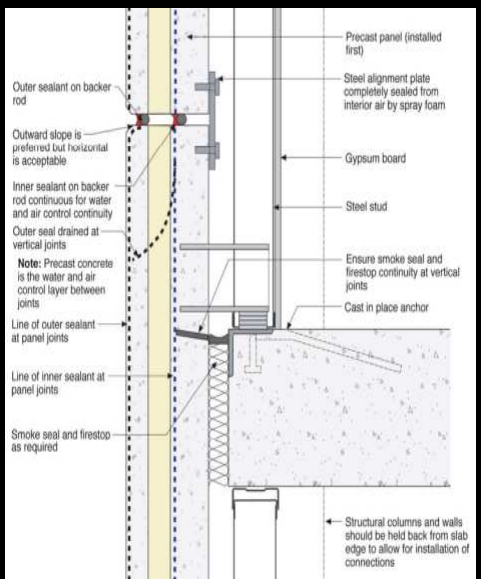
Two Main Types

1) **Single Wythe Precast Concrete Wall Panels**
   a) **Load Bearing and Non-Load Bearing**
2) **Double Wythe Insulated Precast Concrete Wall Panels**
   a) **Composite and Non-Composite**
   b) **Load Bearing and Non-Load Bearing**

Single Wythe



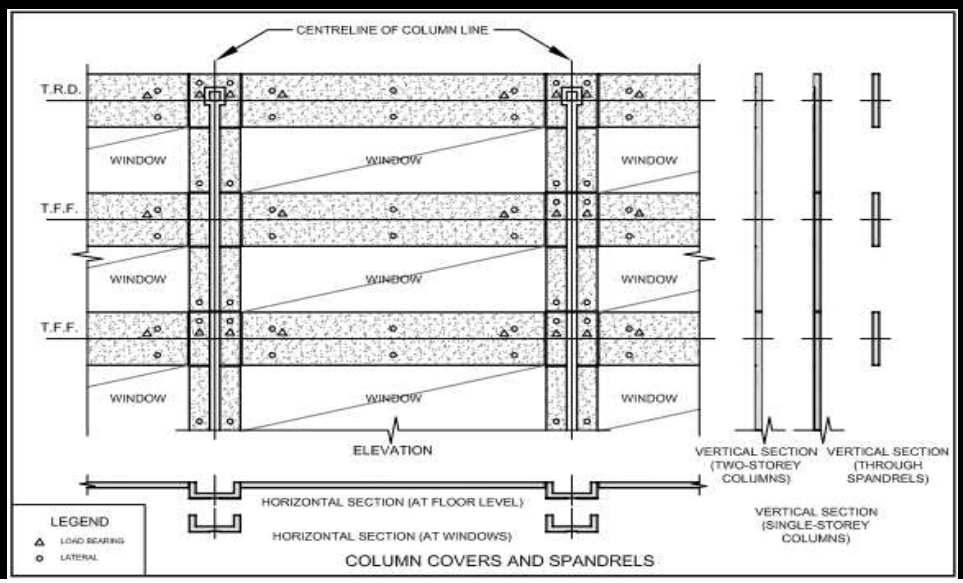
Double Wythe Insulated



2.2 Panel Configuration

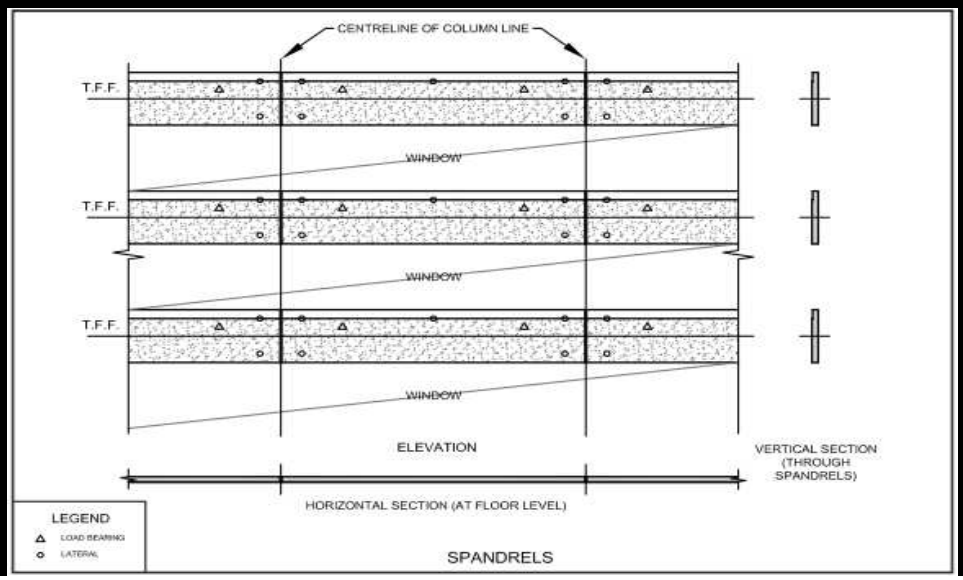
- Horizontal Panels With Column Covers
- Spandrel panels (Bands of Windows and Precast)
- Punched Window Panels
- Solid Panels

Horizontal Panels with Column Covers



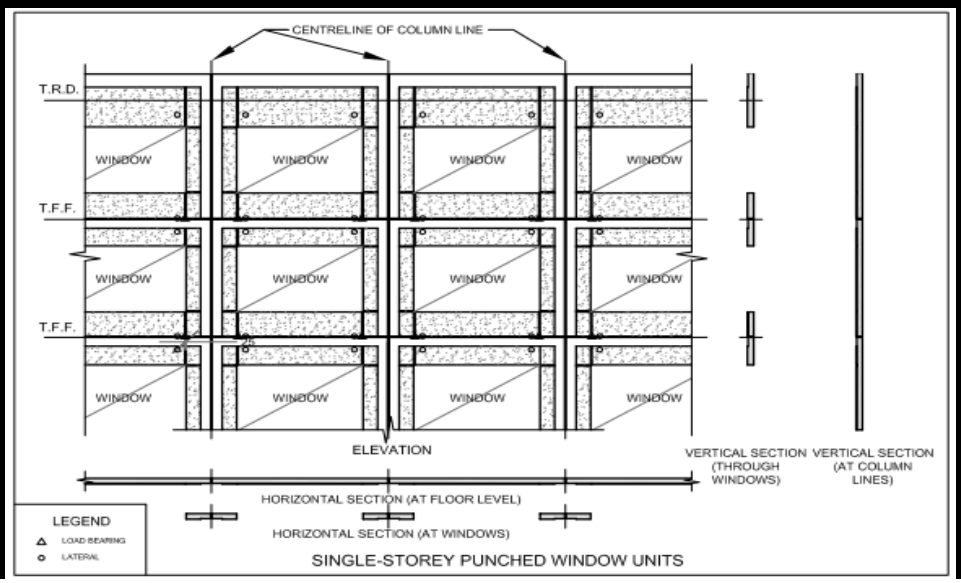
Horizontal Panels with Column Covers

Spandrel Panels



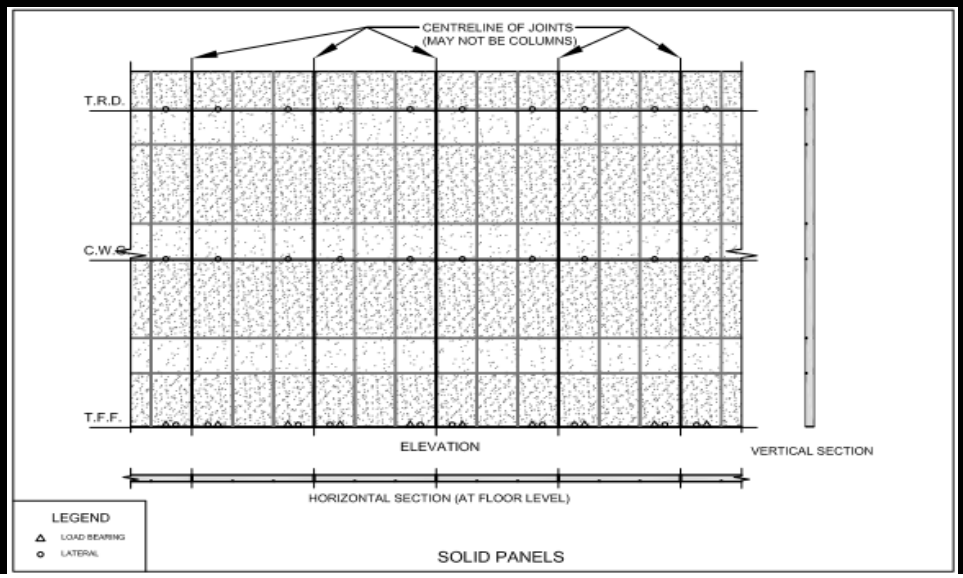
Spandrel Panels

Punched Window Panels



Punched Window Panels

Solid Panels



Solid Panels

2.3 Panel Layout - Jointing

Larger Panels

- Fewer Joints
- Fewer Pieces
- Fewer Connections
- Shorter Joint Length
- Faster Installation

2.4 Aesthetics

- Colour – Overall Colour and Fleck
  - Hue, Saturation and Brightness
  - Background and Feature
- Texture – Surface Features and Quality
  - Reveals, Accents, Medallions
- Finish – Surface Appearance
  - Acid Etch, Sand Blast, Exposed, Honed, Polished

Aesthetics - Colour

- Use Aggregates (Coarse and Fine)
  - Depth of Exposure
  - Size of Aggregate
  - Gradation of Aggregate
- White and/or Grey Cement
- Use Pigment

Aesthetics - Texture

- Forms
- Form Liner
  - Standard – from Catalogue
  - Custom - Unlimited – Anything Is Possible
- Other Materials
  - Brick, Granite, Marble, Limestone, Sandstone
  - Smooth Faced, Rough cut, Flamed, Polished

Formliner - Standard

Formliner - Custom

Repetition for Economy

Aesthetics - Finish

Lowest Cost ↓ Highest Cost

- **Smooth As-Cast** – smooth film of hardened cement matrix.
- **Acid Etching** – typically light to medium exposures.
- **Sand or Abrasive Blasting** – cement and sand removed from the surface so that course aggregate becomes the major surface feature.
- **Exposed Aggregate** – by chemical retarders and water washing.
- **Honed or Polished** – matte or high luster (by grinding)
- **Tooling or Bushhammering**
- **Hammered Rib or Fractured Fin**
- **Sand Embedment**
- **Clay Product-Faced** – brick, ceramic tile, porcelain, or terra cotta
- **Stone Veneer-Faced** – granite, limestone, marble, sandstone, slate …

3.0 Manufacturing

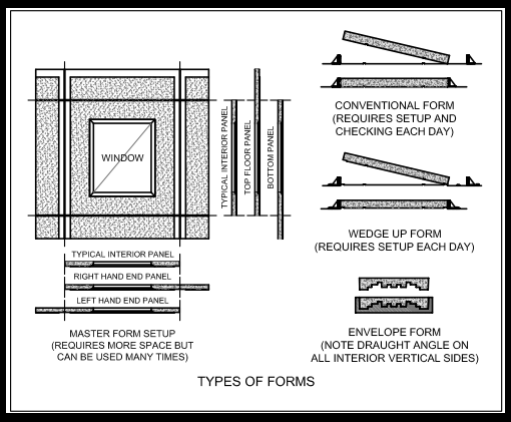
- Forms
- Materials and Quality Control
- Transportation
- Installation

3.1 Forms

Form Materials

- **Wood –**
  - Plain – 1 or 2 uses
  - With Resin – 3 to 5
  - Glassed – 5 to 50+
- **Styrofoam**
- **Fibreglass**
- **Steel**
- **Concrete**
- **Combination**

Forms



Form Types

- **Conventional**
  - **All Sides Moveable**
- **Wedge Up Conventional**
  - **Sides Abut Raised Face**
- **Master Form**
  - **All Edges have Draft (slope)**

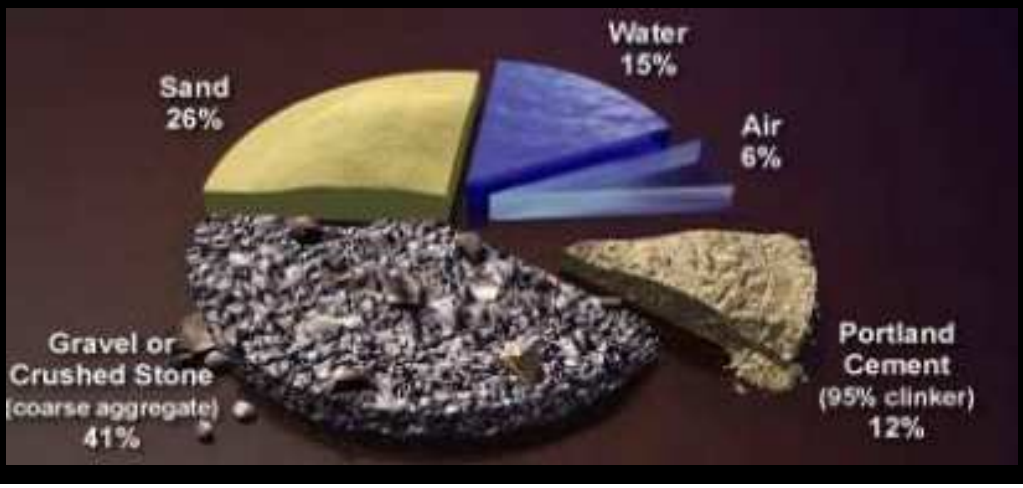
Forms

Column Form

Radial Wall Form

3.2 Materials

Concrete



Concrete Options

- Cement (Grey, White) (High Early, Portland, PLC)
- Supplementary Cementitious (Fly Ash, Silica Fume, Slag)
- Aggregate (Coarse, Fine) (Colour, Texture, Tone)
- Admixtures (Air, Water Reducer, Plasticizer, Viscosity)
- Pigment (Matrix Colour)
- Water (Potable)

3.3 Transportation

- Trailer Types
  - Flat Bed (shown)
  - Drop Deck
  - A-Frame
  - Specialty
- Clearances (Bridges)
- Capacities (Load Limits / Wheel Loads)
- Seasonal Load Restrictions (Frost)

3.4 Installation

Tower Crane

- Storage on Site
- Turning Frame
- Limited Capacity
- Limited Times of Use

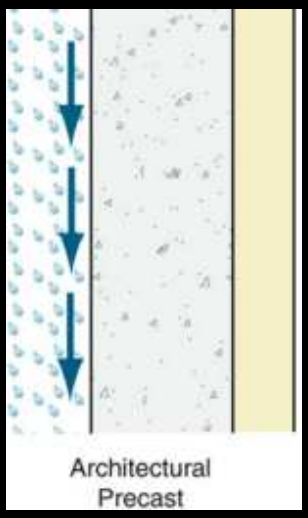
Mobile Crane

- Truck to Building
- Limited Height
- Greater Capacity
- Setup Area

4.0 Performance

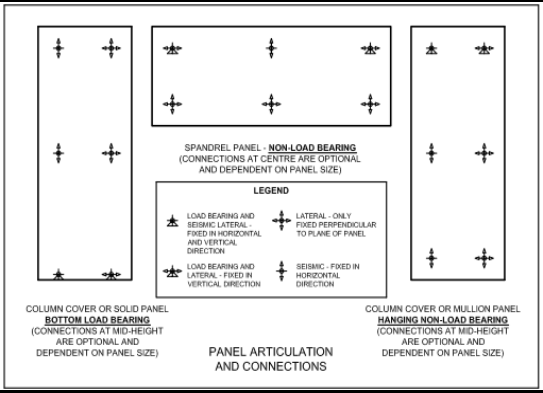
- Building Envelope Functions
- Structural Considerations
- Fire Resistance
- Durability and Life Cycle
- Energy
- Aesthetics

4.1 Building Envelope Functions



- Water Shedding
- Air Flow
- Heat Flow
- Water Vapour Transmissions
- Light and Solar Radiation
- Noise

4.2 Structural Considerations

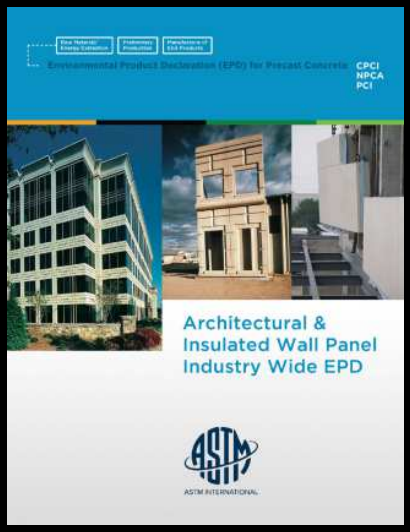


- Panel Strength
- Panel Articulation
- Connections
  - Gravity
  - Lateral
  - Seismic
- Seismic Response

4.3 Fire Resistance

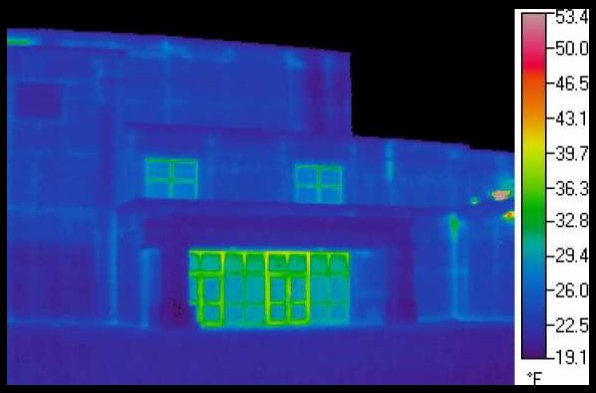
- Concrete DOES NOT Burn
  - Not a Fuel Source
- Double Wythe Panels – (Insulation is Encapsulated)
  - Limited Access to Flame
- 90 mm – 1 Hour Rating
- 4 Hour Rating Possible

4.4 Durability and Life Cycle



- Life Span (60 - 100 Years+)
- Minimal Maintenance
- Sealant is Weak Link - "Achilles Heel"
- Life Cycle Assessment
- EPD's Available

4.5 Energy



- Insulation
  - Type
  - Thickness
- Window/Wall Ratio
- Thermal Mass
- Air infiltration
- Air Exfiltration

4.6 Aesthetics

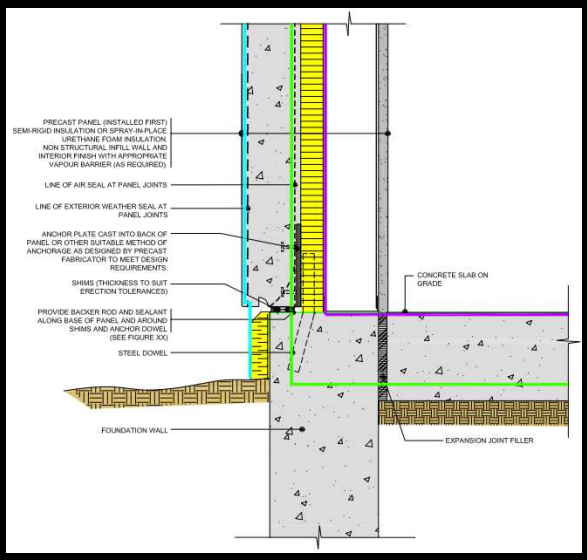
Anything is Possible

- Colour – Cement, Stone, Sand, Pigment
- Texture – Forms, Form Liner
- Finish
  - Acid Etch
  - Sand Blast
  - Exposed Aggregate
  - Bush Hammer
  - Polish

5.0 Detailing

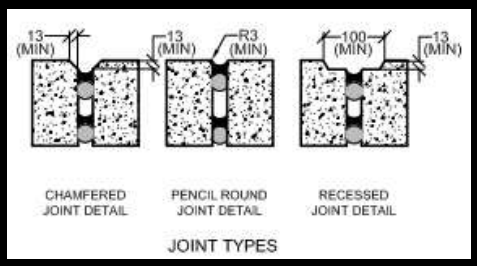
- Performance Criteria
- Panel Design/Detailing
- Joint Design/Detailing
- Joint Considerations
- Sealant Selection and Economics
- Continuity

5.1 Performance Criteria



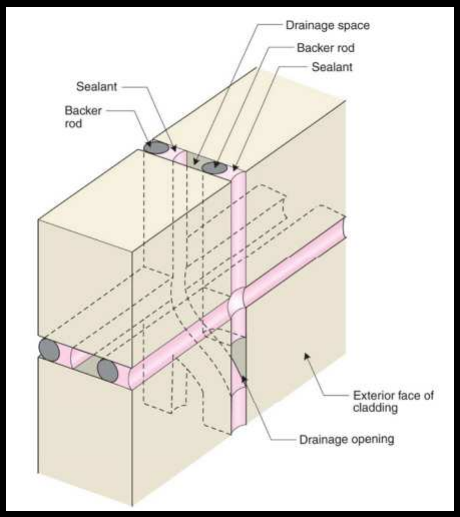
- Air Control
- Water Control
- Vapour Control
- Thermal Control
- Durability
- Maintainability

5.2 Panel Design / Detailing



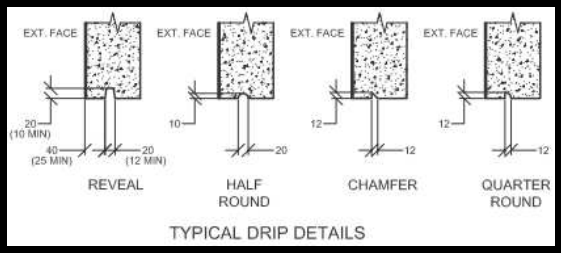
- Panelization
- Wythe Thickness/es
- Strength - Reinforcing
- Insulation Thickness
- Edge / Reveal Treatment
- Connection Hardware
- Handling Hardware

5.3 Joint Design / Detailing



- Drip Edges
- Panel Profile at Joint
- Type of Joint
  - Single Stage (not recommended
  - Two Stage Drained
- Sealant Selection
- Joint Movement
- Vent and Baffle Location

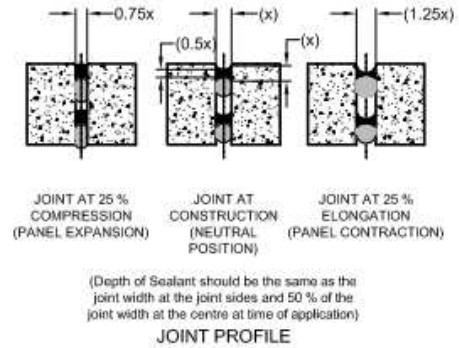
Panel Drip Treatment



TYPICAL DRIP DETAILS

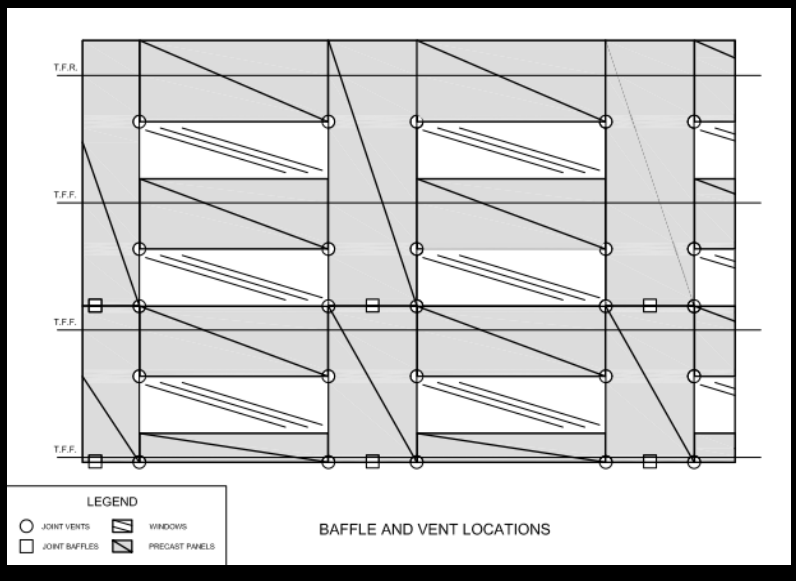
- Required on Bottom Edges
- Typical Shapes
- Vertical Face
- Minimum Sizes
- Minimum Setbacks from Face

5.4 Joint Considerations



- Capabilities of Sealant
- Joint Width
- Joint Shape
- Temperature Range
- Panel Dimensions
- Installation Temperature

Vent and Baffle Locations



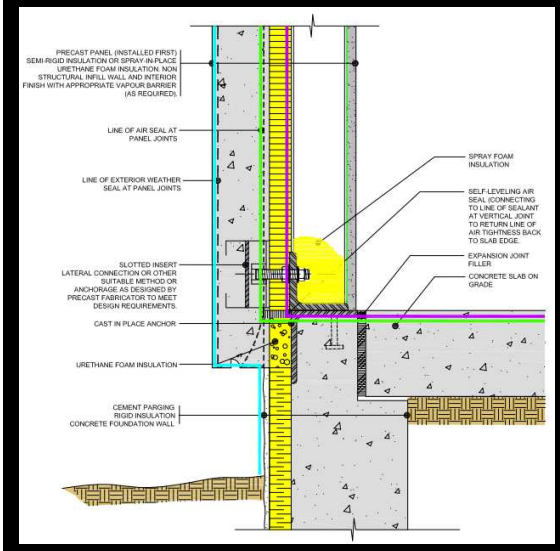
5.5 Sealant Selection / Testing

- Three Main Types
  - Polyurethane
  - Silicone
  - Hybrid
- Check Dimensions of Profile
- Pull Test
  - Adhesion
  - Cohesion
  - Profile

Sealant Economics

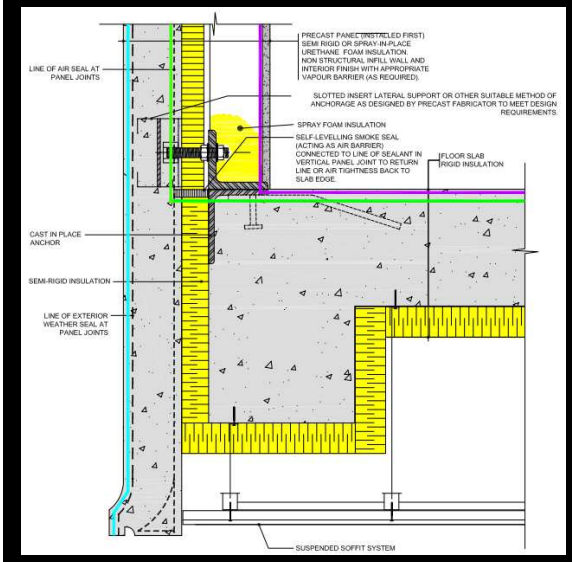
- **Choose Best Possible**
  - **$50,000,000 Project**
  - **~$500,000 Sealant Contract (~1%)**
  - **~$100,000 Sealant Material Cost (~20 to 30%)**
  - **Best May Double Sealant Cost - ~$200,000**
  - **$500,000 / 5 Years - $100,000 Per Year - Cheapest**
  - **$600,000 / 25 Years - $24,000 Per Year – Best**
  - **Pay Extra $100,000 in Just Over First Year with Cheapest**
  - **Does Not Include Removal and Replacement Costs**

6.0 Sample Details



- Tie Ins with Other Materials
- Continuity
- Constructability
- Repairability

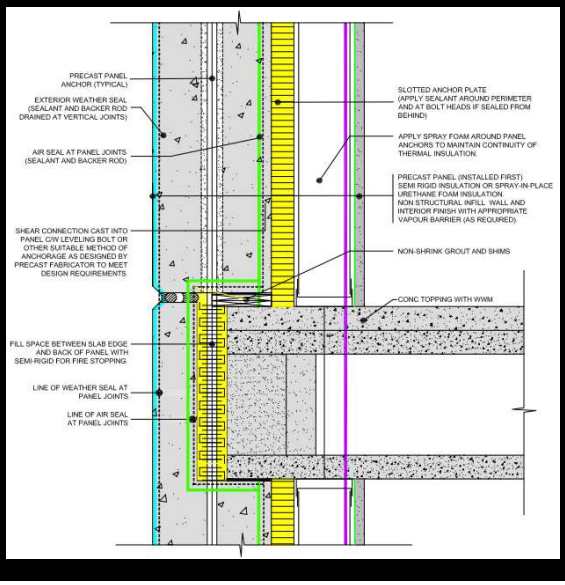
Details – Single Wythe



At Soffit

Vapour control layer
Air control layer
Heat control layer
Precipitation control layer

Details – Single Wythe

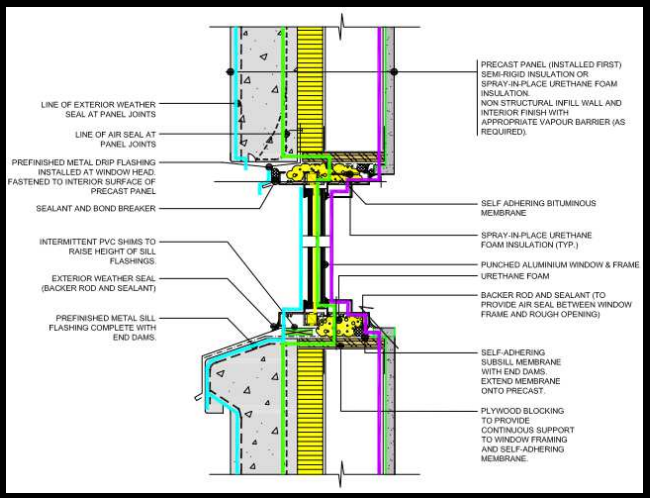


Load Bearing
(Hollow Core)

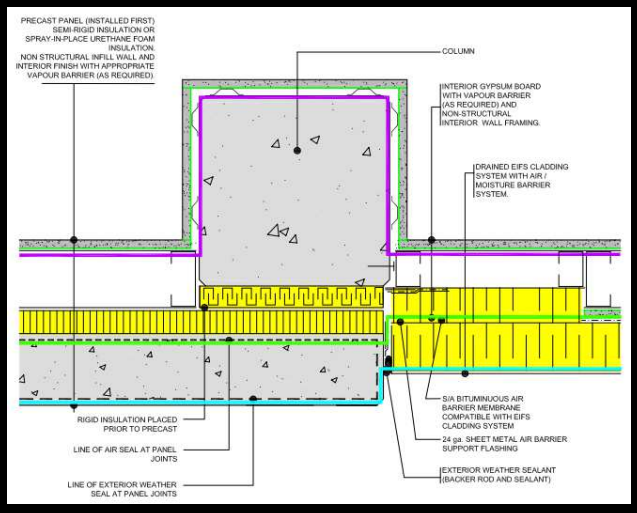
Vapour control layer
Air control layer
Heat control layer
Precipitation control layer

Details – Single Wythe

At Window

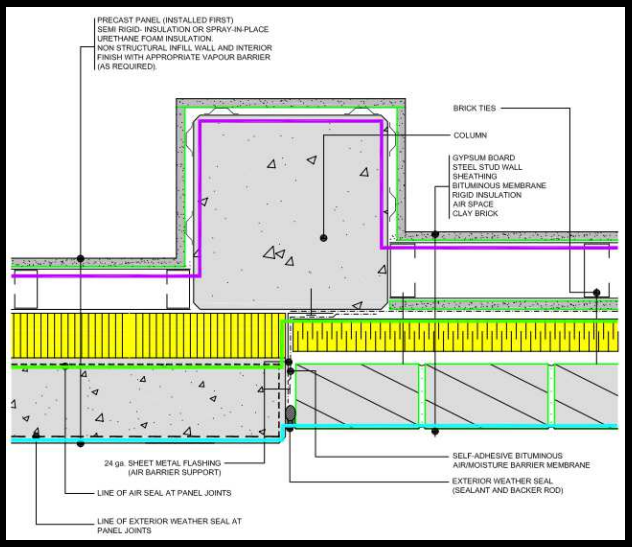


Details – Single Wythe



Transitions To EIFS

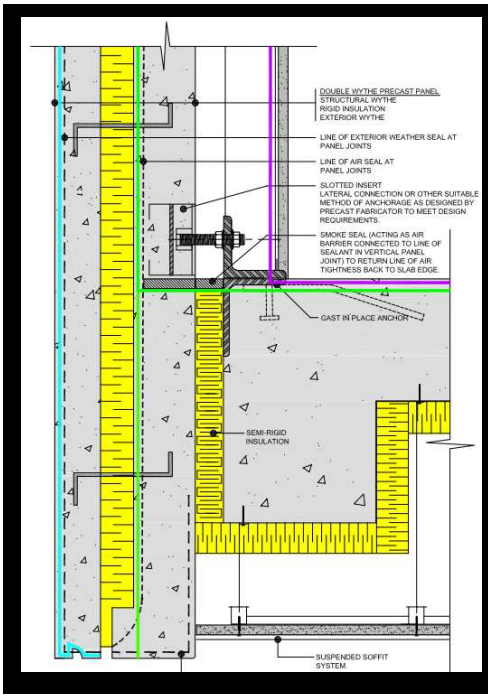
Details – Single Wythe



Transitions (To Brick)

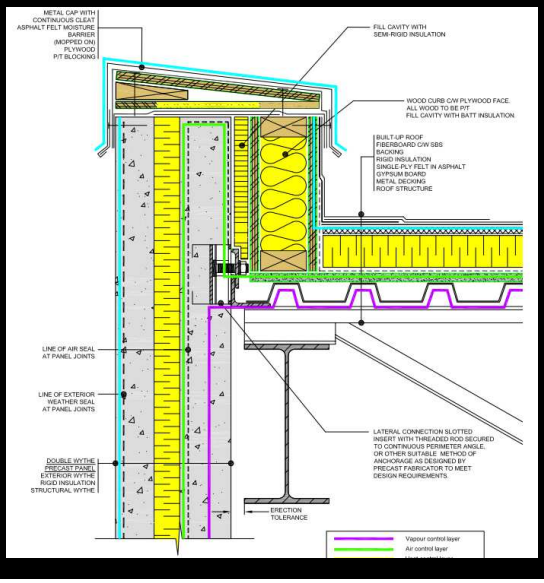
Details – Double Wythe

At Soffit



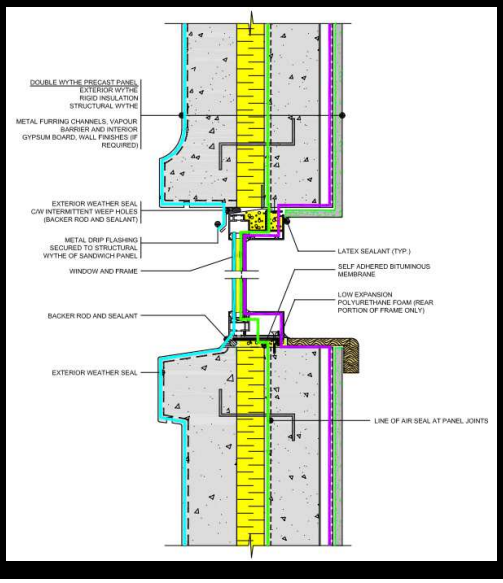
Vapour control layer
Air control layer
Heat control layer
Precipitation control layer

Details – Double Wythe



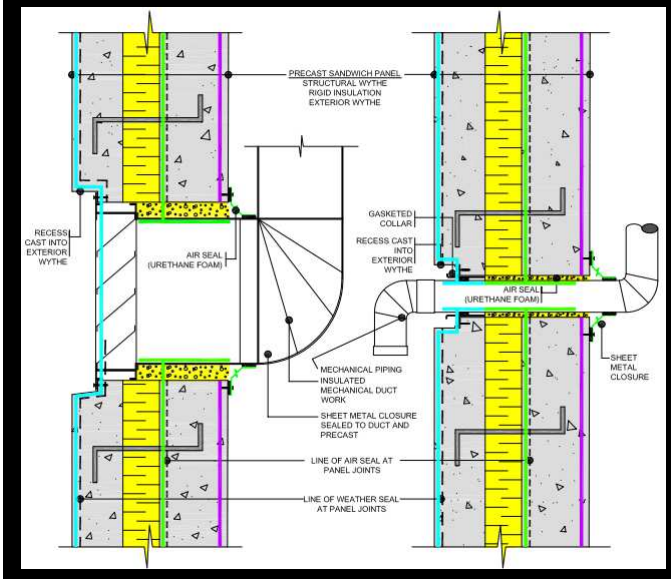
At Parapet

Details – Double Wythe



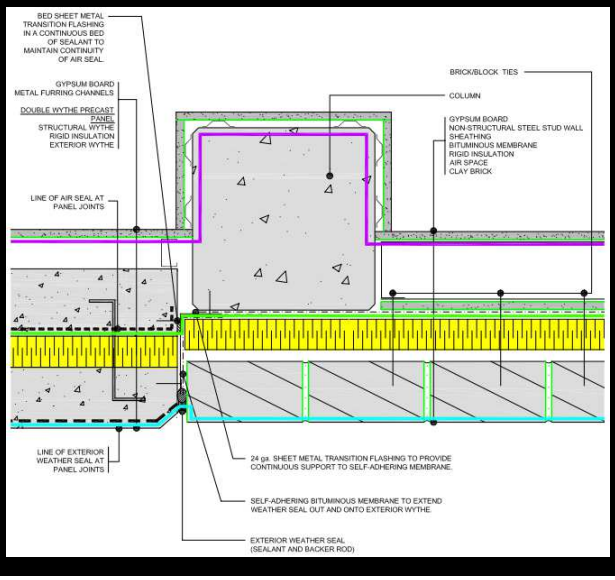
At Windows

Details – Double Wythe



For Mechanical

Details - Double Wythe



Transitions (To Brick)

7.0 Construction

- Design
- Tender
- Detailing
- Samples
- Quality Assurance
- Sustainability and LEED

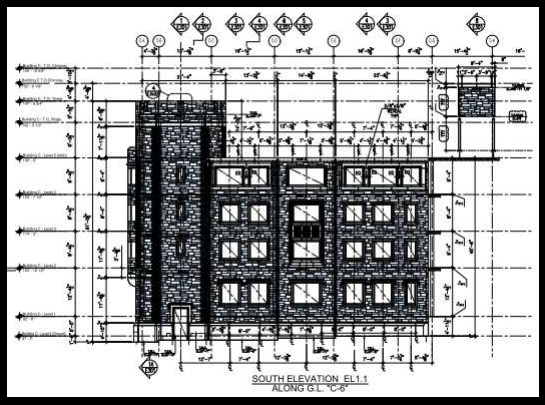
7.1 Design

- Ask for Assistance From Precasters
- Have Precasters Review Specifications
- Get Samples
- Send Out Complete Design
  - Better to Wait Than Incomplete
  - Incomplete - Costs Money
  - Not Sure - Adds Money

7.2 Tender

- Place Value on Precaster's Assistance
  - Knows Project Better – Less Likely for Extras
- Review Tender – Complete
  - If Not Complete – Disqualify
  - Be Open – Be Tough
- Check References
- Review Previous Projects
- Make Sure Sufficient Time To Produce
  - Maximum 10 to 15 Panels per Day

7.3 Detailing



- Allow Time to Detail
- Review Precast Shops for Questions
- Provide Answers Where Needed
- Review In Timely Manner
- Make Review Count

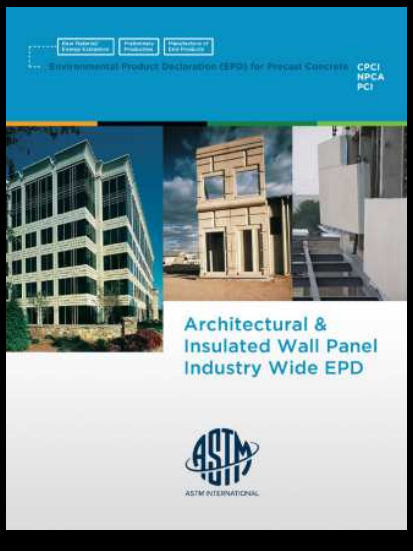
7.4 Samples

- **Architectural Samples** – 300 x 300 For Colour
- **Range Samples** – 1200 x 1200 For Consistency / Patching
- **Mockups** – Verify Design Intent (Appearance)
- **Mockup Testing** – Verify Performance (With other Trades)

7.5 Quality Assurance

- Specify CPCQA Certification Prior to Award
  - Prior to January 1, 2018 - CPCI
  - Capable of Producing Quality Product
  - Capable of Producing Type of Product
- Plant Visit Prior to Award
- Plant Visit Prior to Production
- Plant Visits During Production
- Review Documentation During and After

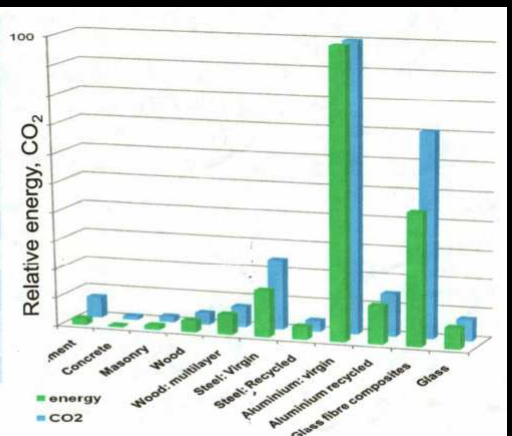
7.6 Sustainability and LEED



- Building Reuse
- Waste Management
- Recycled Content
- Regional Materials
- Durable Building
- Environmental Product Declaration (EPD)

Environmental Footprint of Materials

Material	MJ/kg	$kgCO_2/kg$
Cement	4.6	0.83
Concrete	0.95	0.13
Masonry	3.0	0.22
Wood	8.5	0.46
Wood: multilayer	15	0.81
Steel: Virgin	35	2.8
Steel: Recycled	9.5	0.43
Aluminium: virgin	218	11.46
Aluminium recycled	28.8	1.69
Glass fibre composites	100	8.1
Glass	15.7	0.85



ICE version 1.6a
Hammond G.P. and Jones C.I
2008 Proc Instn Civil Engineers
www.bath.ac.uk/mech-eng/sert/embodied/

High Performance Attributes and Benefits of Precast

VERSATILE	EFFICIENT	RESILIENT
Aesthetic Versatility	**Site Efficiency**	**Structure Durability**
Virtually any color, form, and texture	Minimal site disturbance	Long service life
Facade integration	Negligible waste	Barrier wall system
Historic compatibility	Accelerated construction	Functional resilience
Structural Versatility	**Energy and Operational Efficiency**	**Multi-Hazard Protection**
Load-bearing envelopes	Scalable performance	Storm resistance
Economical sections	Thermally efficient	Earthquake resistance
Long open spans	Low life-cycle costs	Blast resistance
Use Versatility	**Risk Reduction**	**Life Safety and Health**
Recyclable	Design assist	Indoor environmental quality
Deconstructive reuse	Reduced detailing and trades	Passive fire resistance
Adaptive reuse	Enhanced profitability	Meets FEMA 361

QUESTIONS
Versatile | Efficient | Resilient
Precast Concrete
CANADIAN PRECAST/PRESTRESSED CONCRETE INSTITUTE
INSTITUT CANADIEN DU BÉTON PRÉFABRIQUÉ ET PRÉCONTRAINT
For more information: www.cpci.ca
Email: Malcolm.meh@gmail.com or
Brianhall@cpci.ca