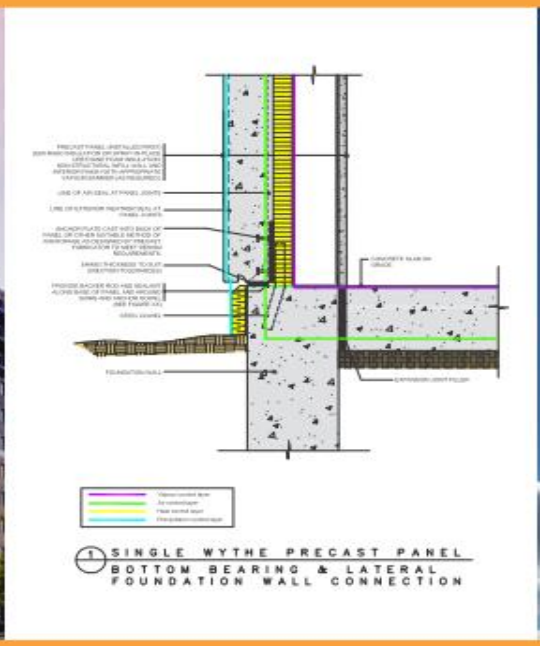
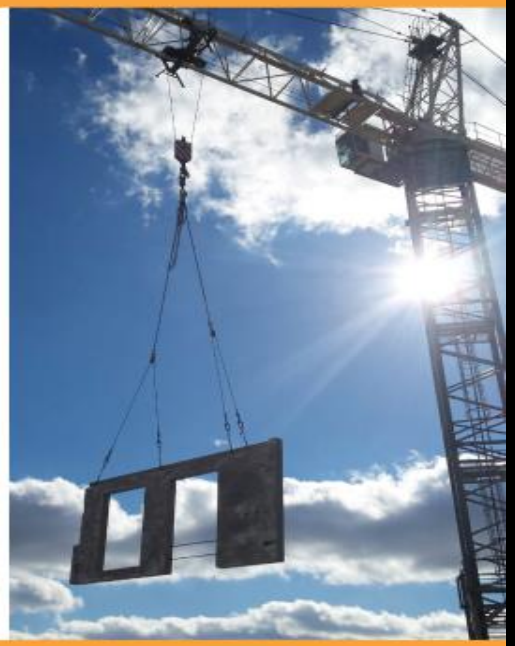
# Architectural Precast Concrete Walls



# Best Practice Guide

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

# Overview

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

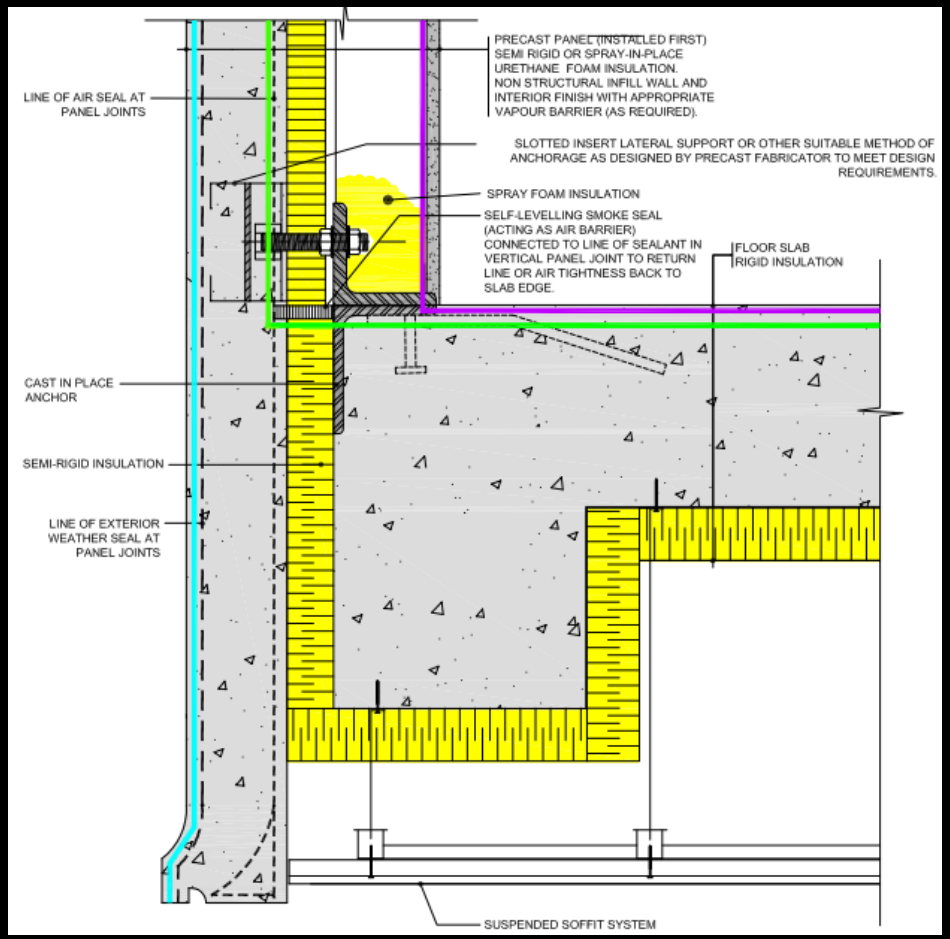
# 1.0 Introduction

- 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

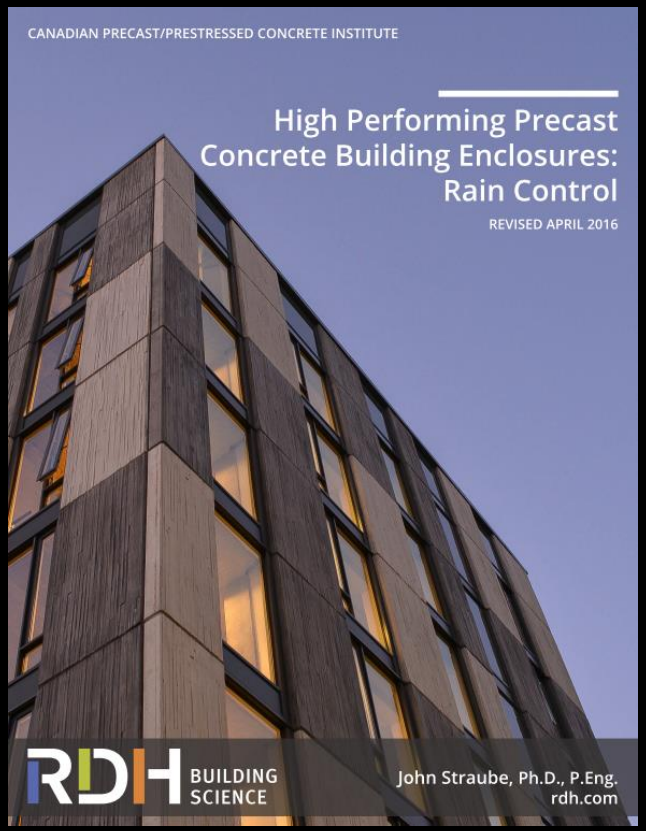
## CPCI does

- 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

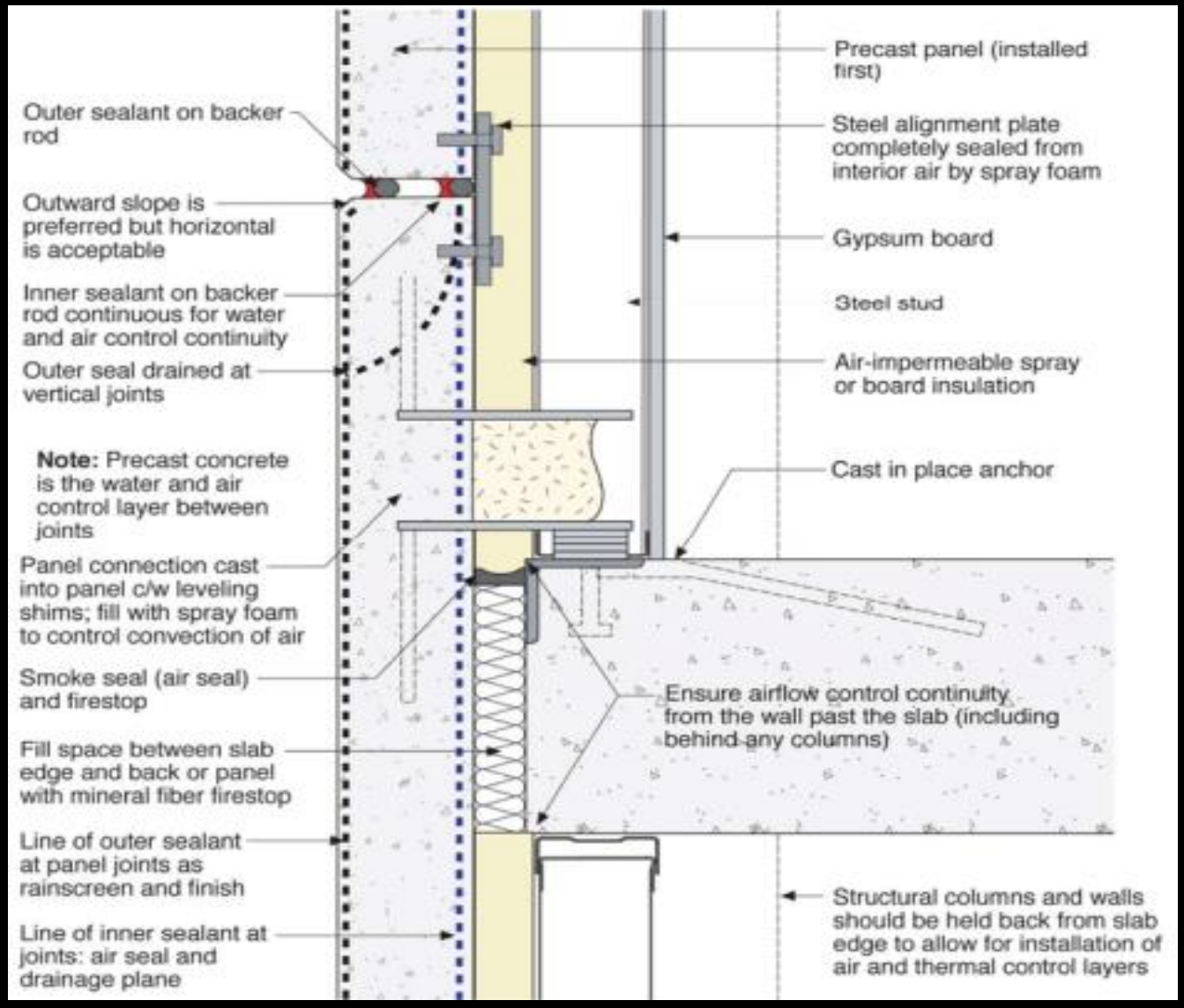
- Panel Types
- Panel Configurations
- Wall Panel Layout – Jointing
- Aesthetics – Colours, Textures, Finishes

# 2.1 Panel Types

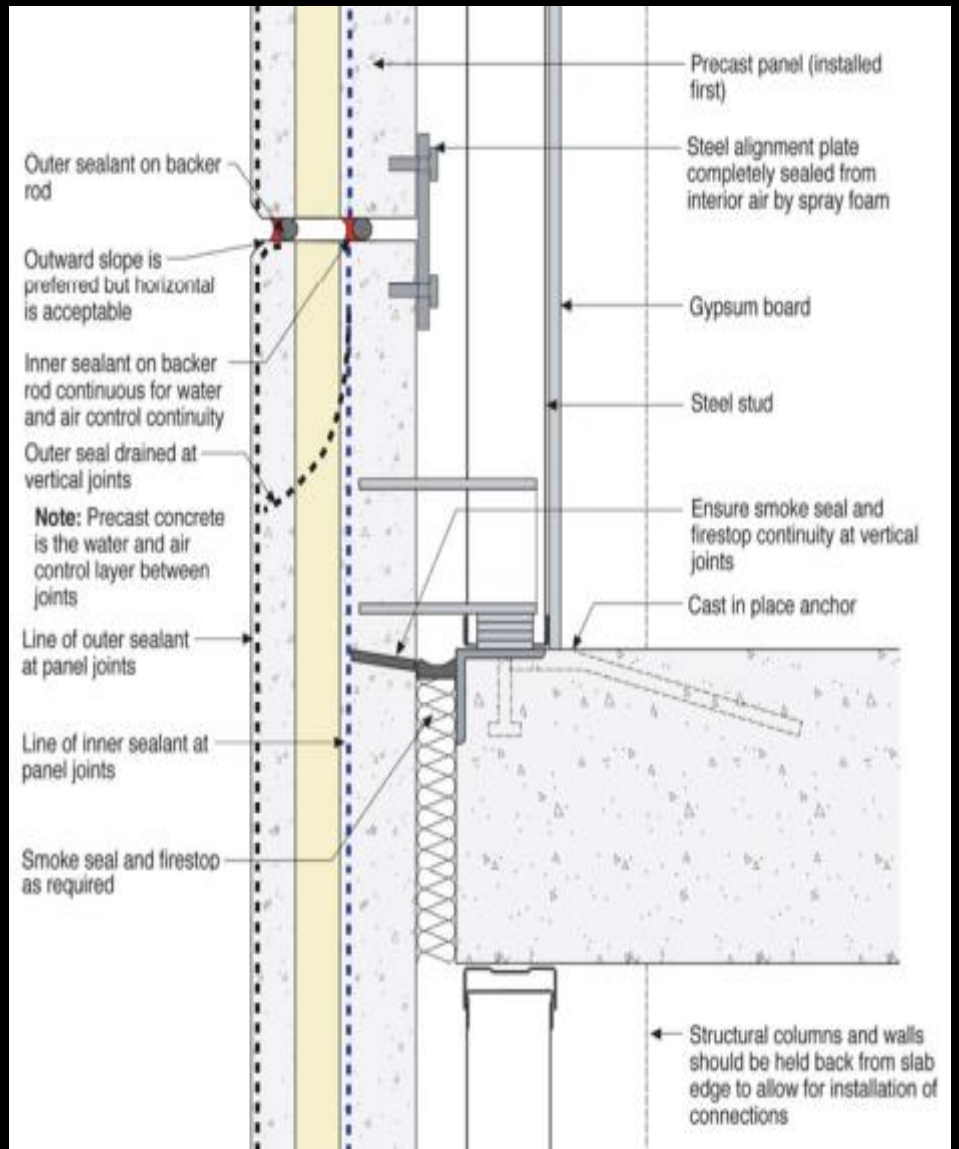
Two Main Types

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



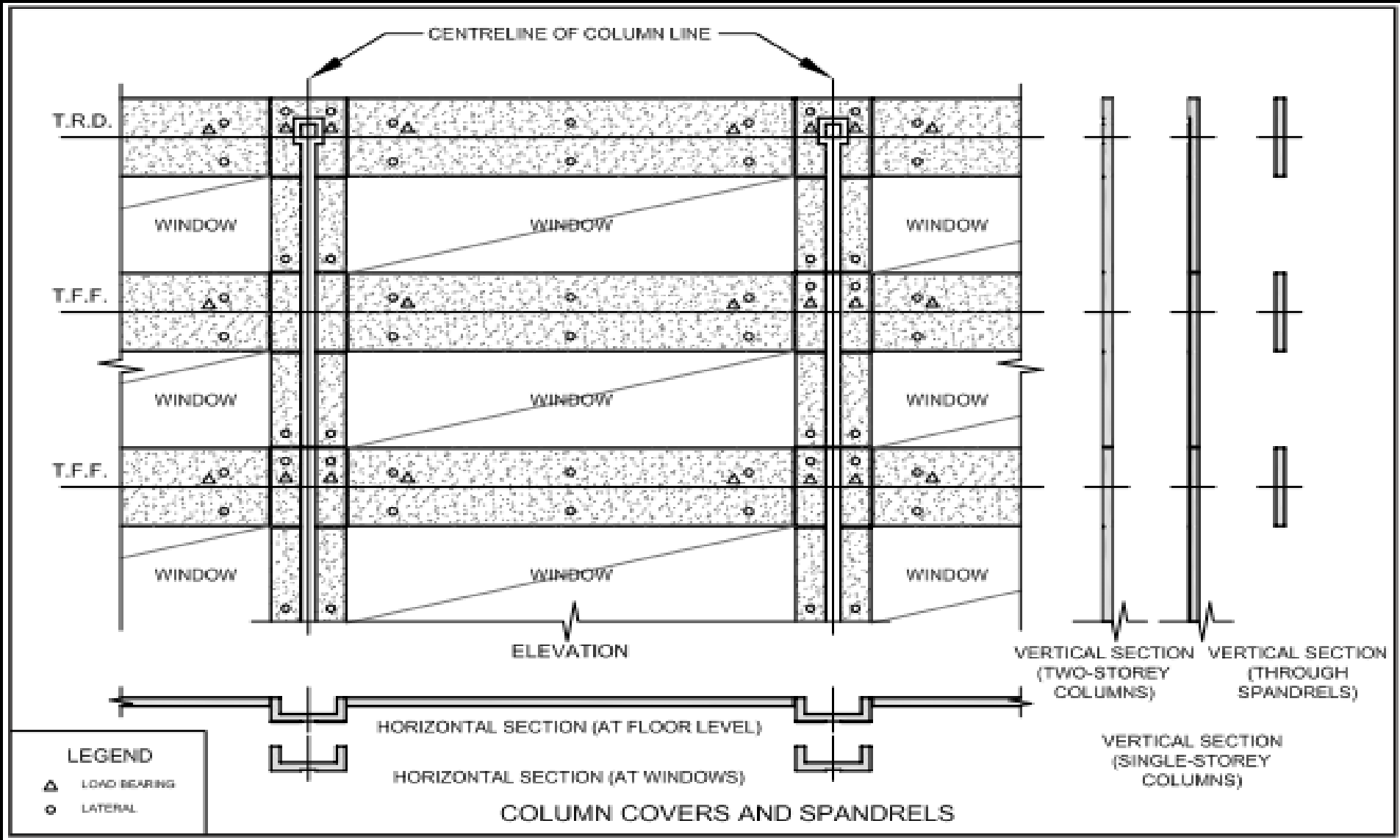
# Double Wythe Insulated



# 2.2 Panel Configuration

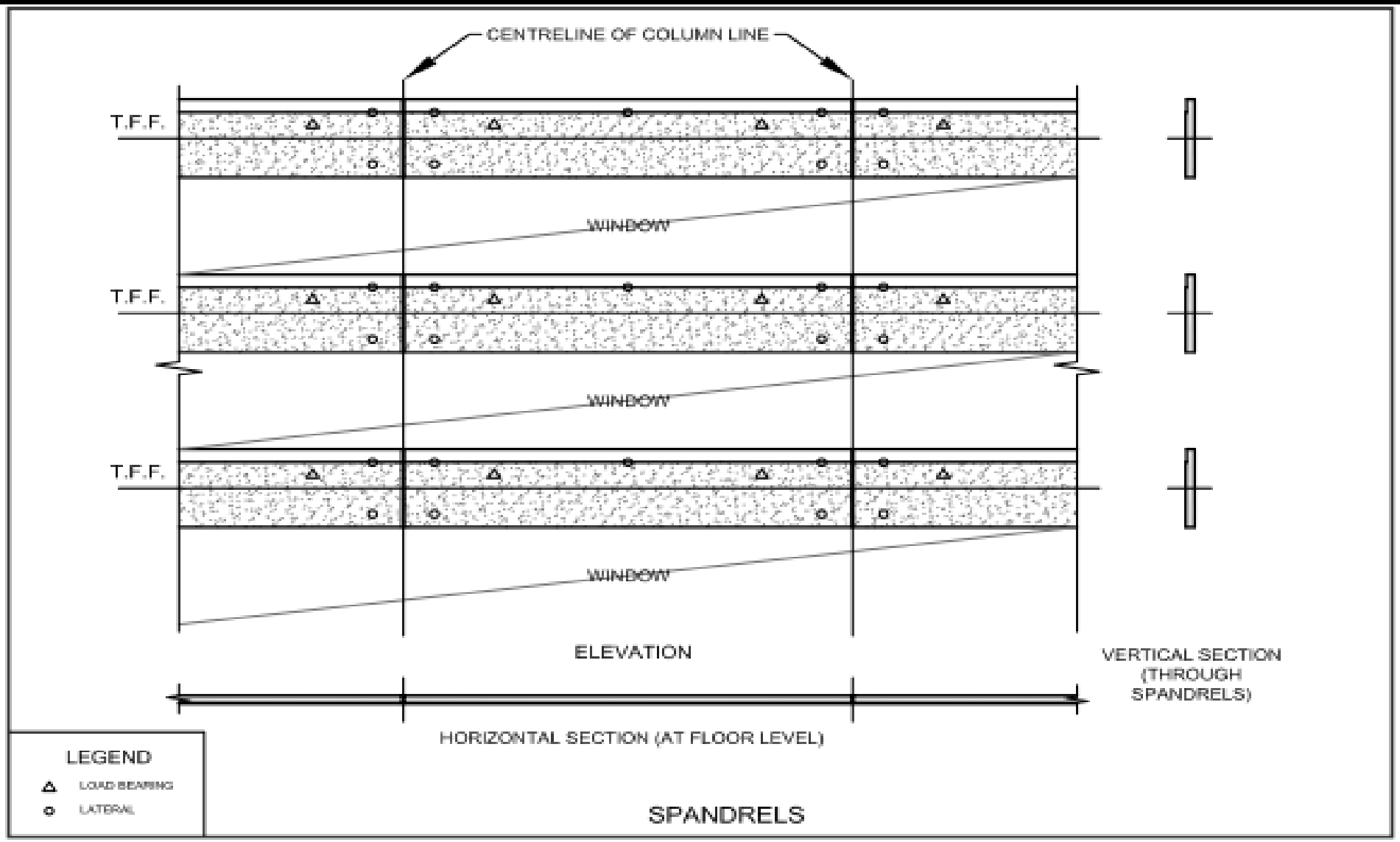
- Horizontal Panels With Column Covers
- Spandrel panels (Bands of Windows and Precast)
- Punched Window Panels
- Solid Panels

# Horizontal Panels with Column Covers



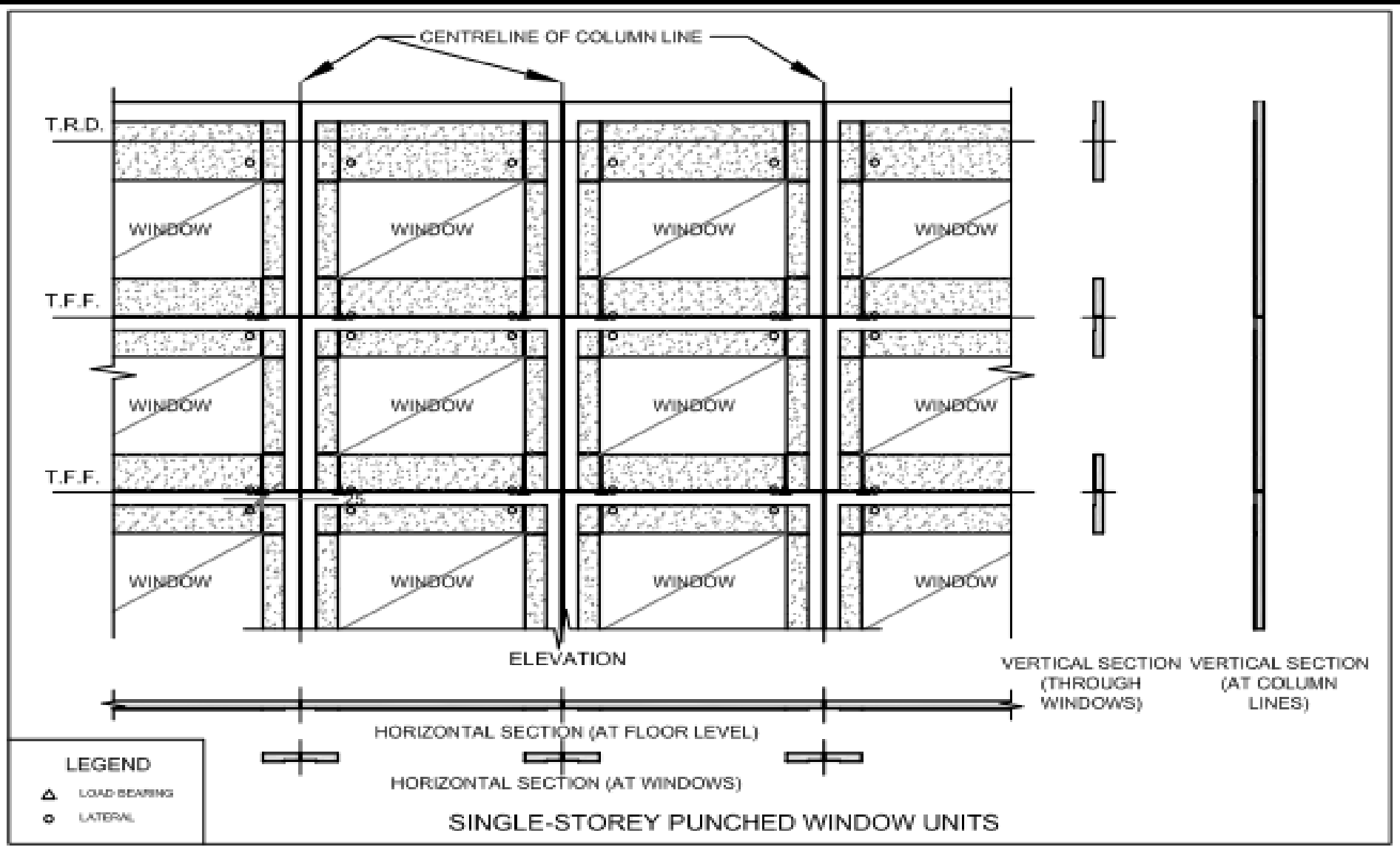
# Horizontal Panels with Column Covers

# Spandrel Panels



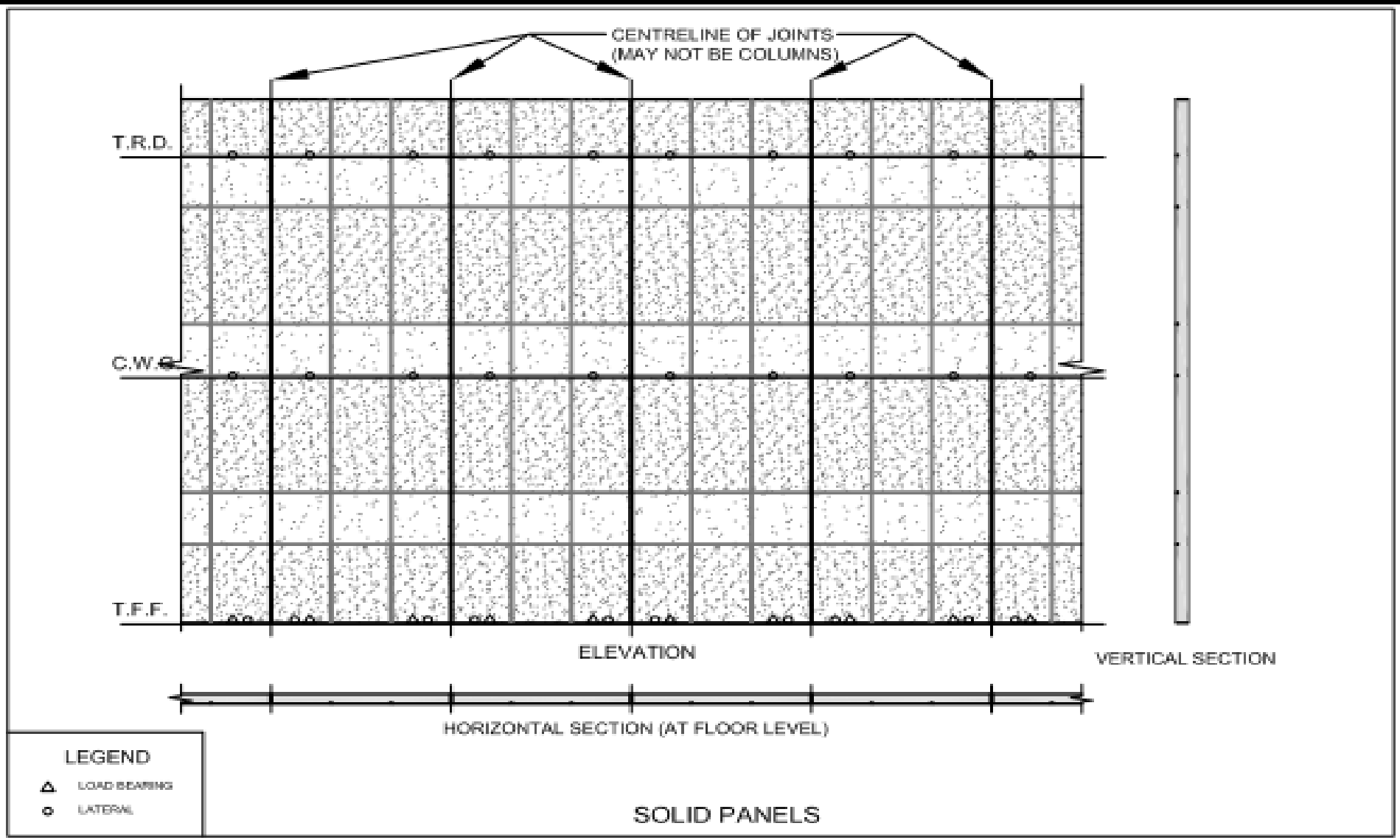
# Spandrel Panels

# 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

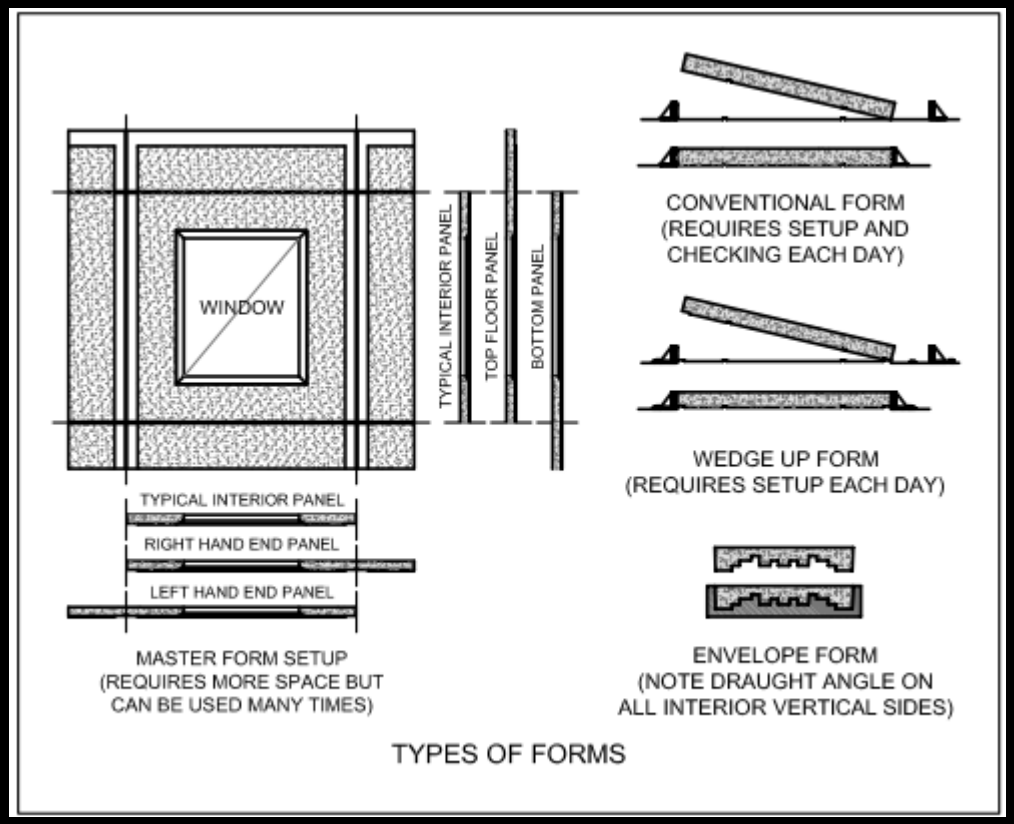
- Forms
- Materials and Quality Control
- Transportation
- Installation

# 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)

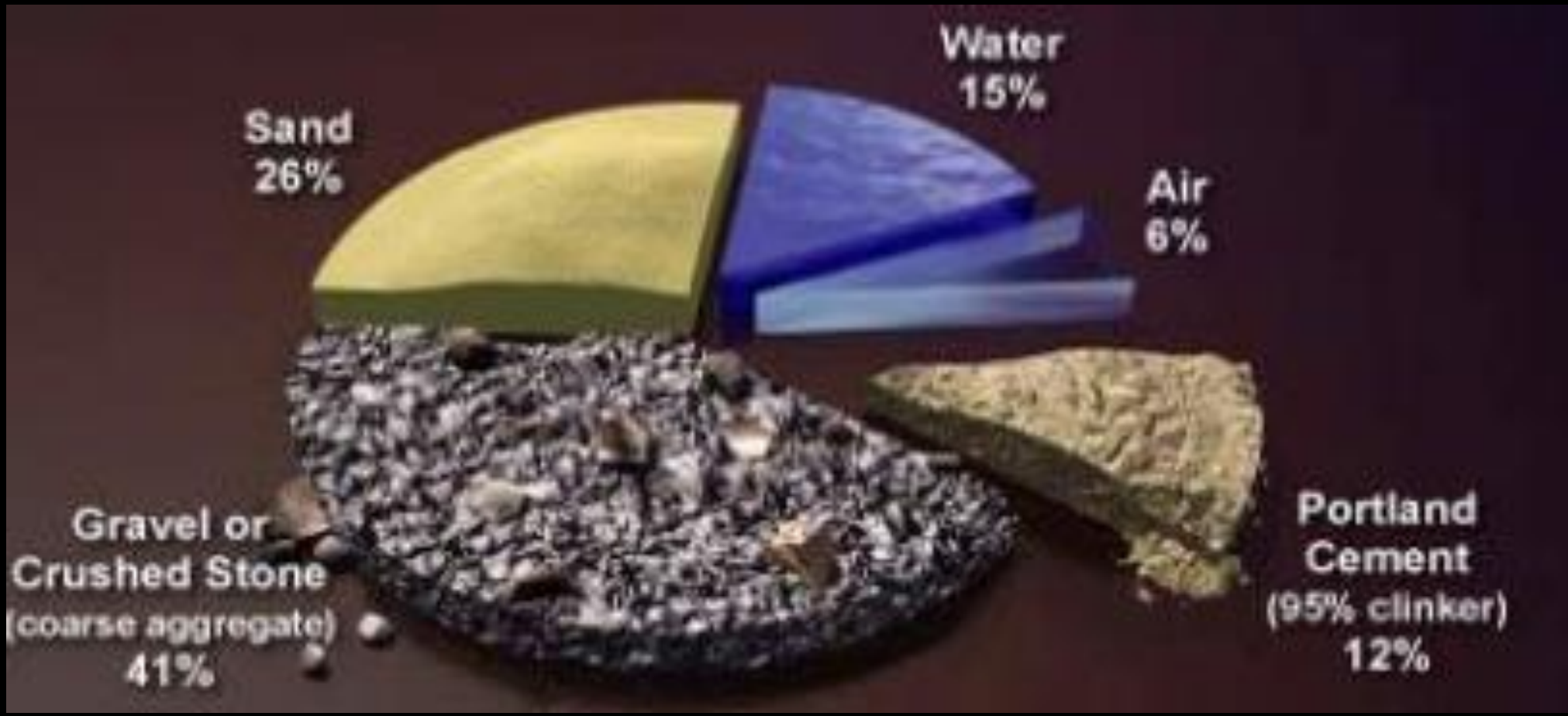
# Forms

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

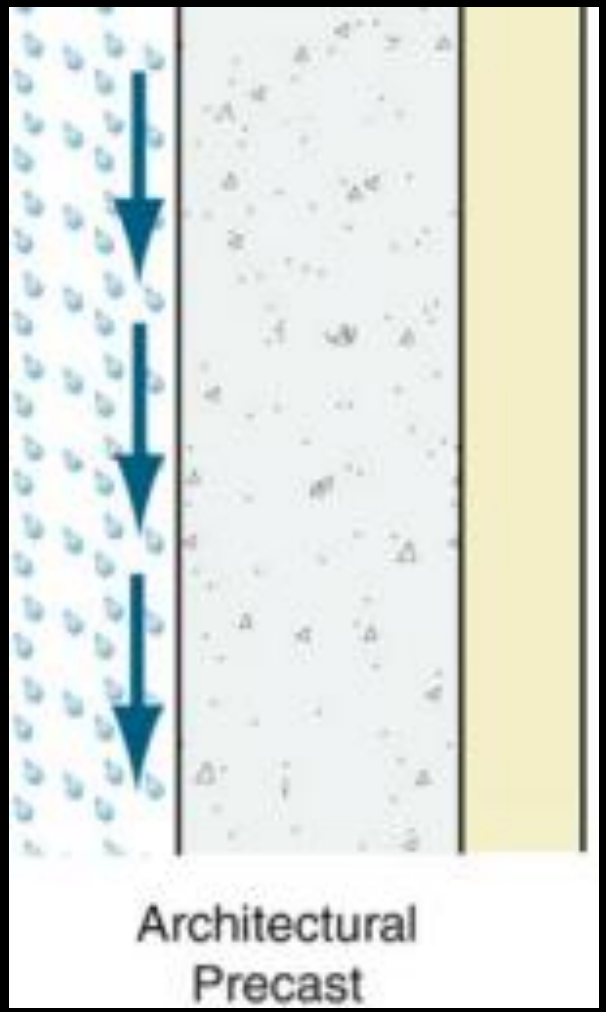
## Mobile Crane

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

# 4.0 Performance

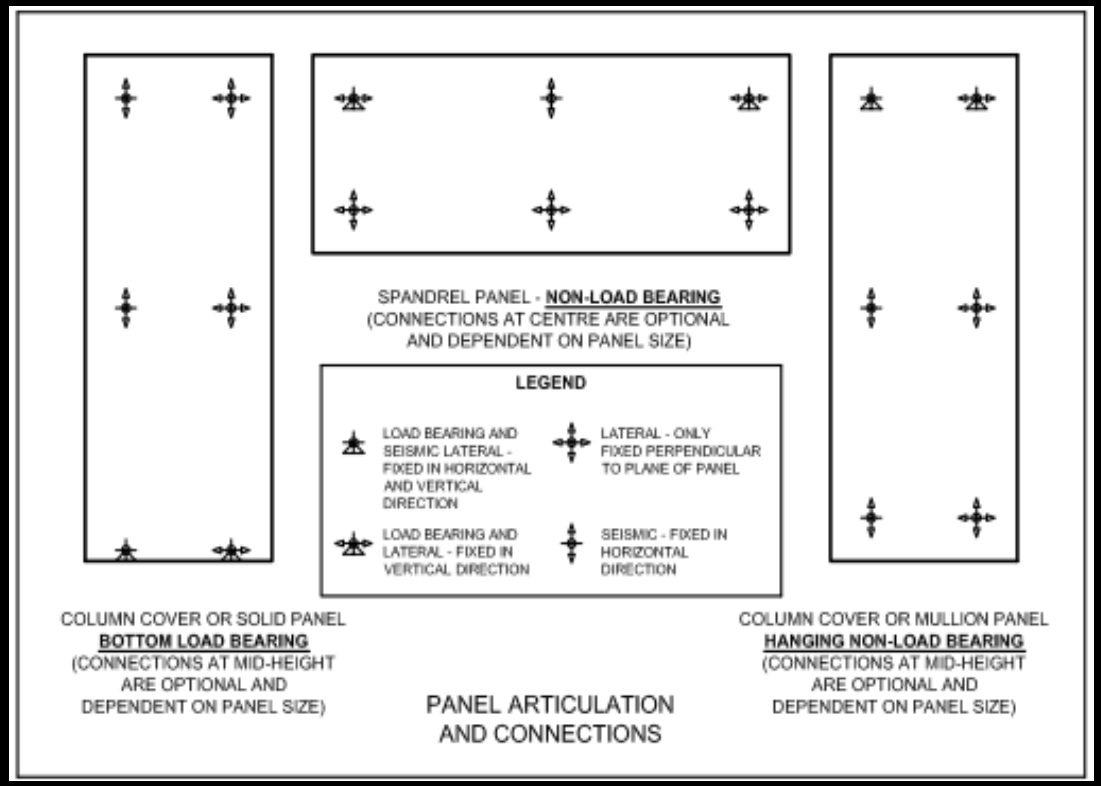
- Building Envelope Functions
- Structural Considerations
- Fire Resistance
- Durability and Life Cycle
- Energy
- Aesthetics

# 4.1 Building Envelope Functions




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

# 4.2 Structural Considerations

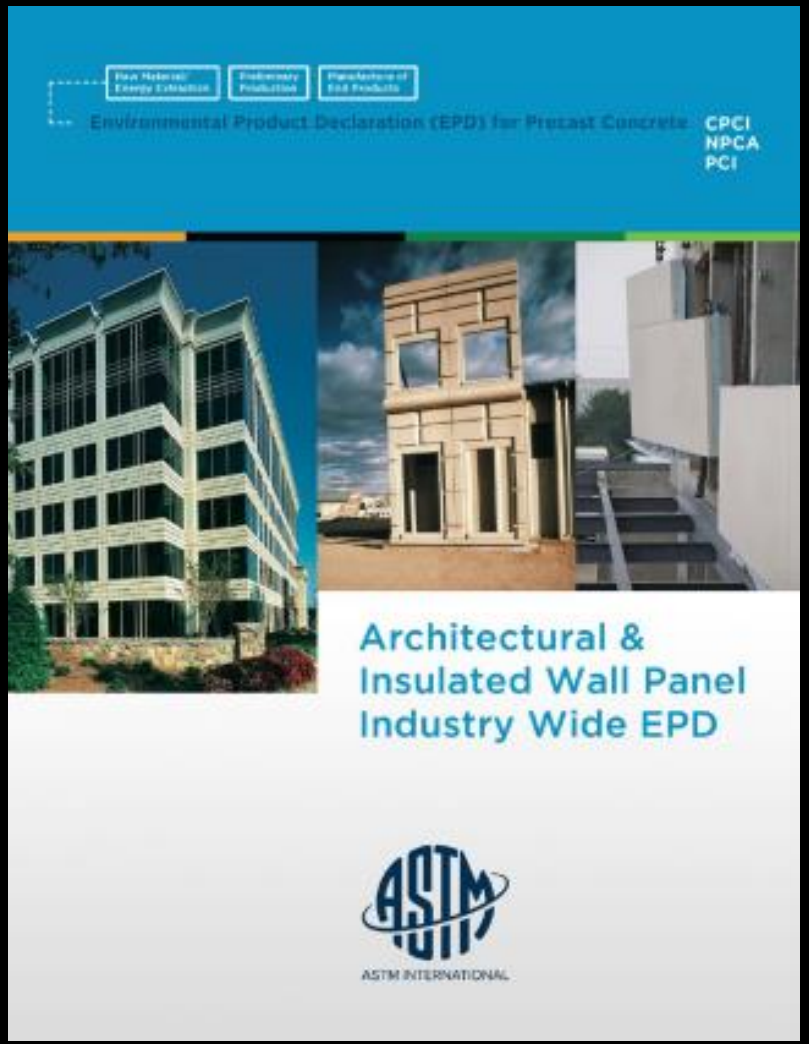



- Panel Strength
- Panel Articulation
- Connections
  - Gravity
  - Lateral
  - Seismic
- Seismic Response

# 4.3 Fire Resistance

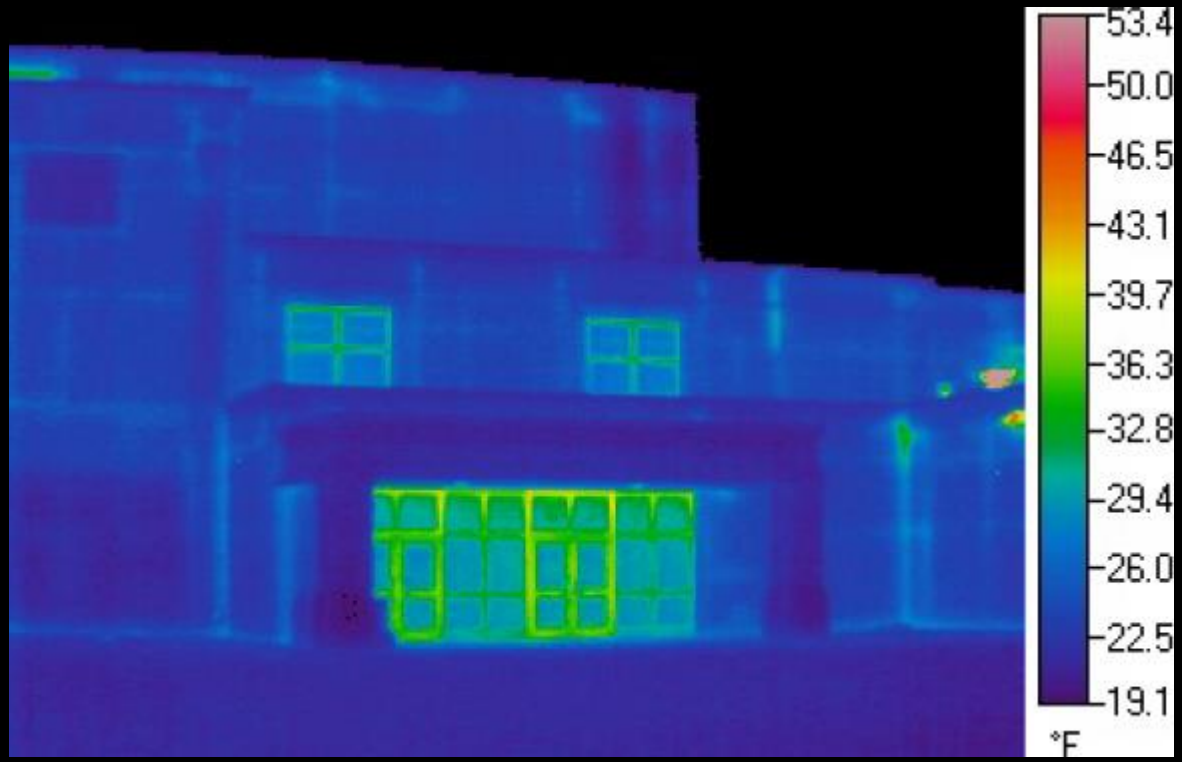
- Concrete DOES NOT Burn
  - Not a Fuel Source
- Double Wythe Panels – (Insulation is Encapsulated)
  - Limited Access to Flame
- 90 mm – 1 Hour Rating
- 4 Hour Rating Possible

# 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

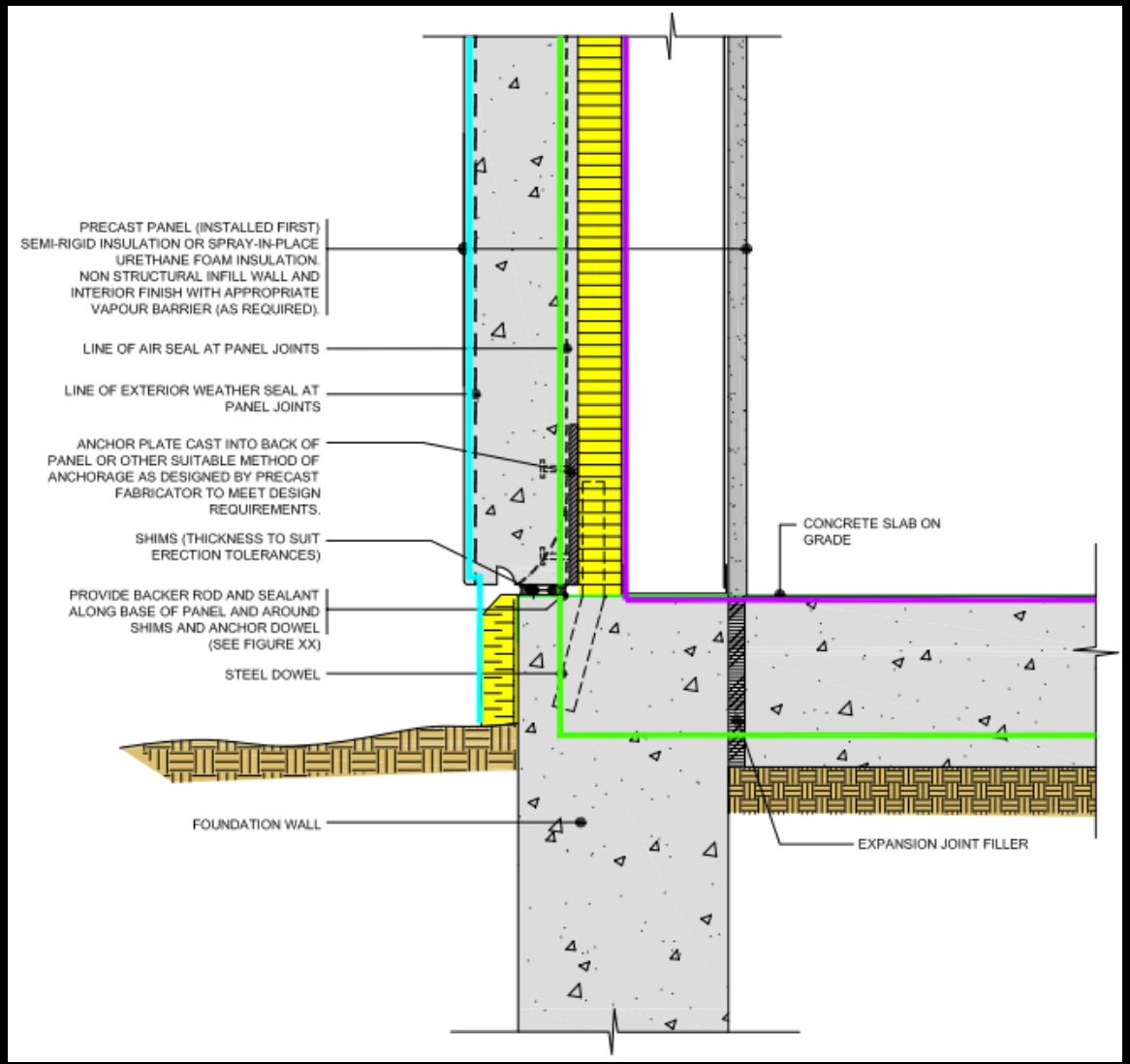
**Anything is Possible**

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

# 5.0 Detailing

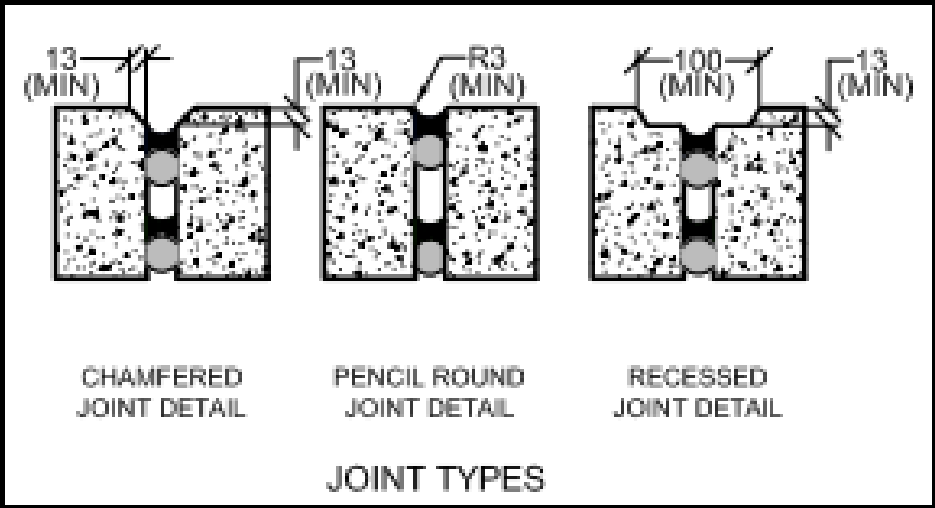
- Performance Criteria
- Panel Design/Detailing
- Joint Design/Detailing
- Joint Considerations
- Sealant Selection and Economics
- Continuity

# 5.1 Performance Criteria



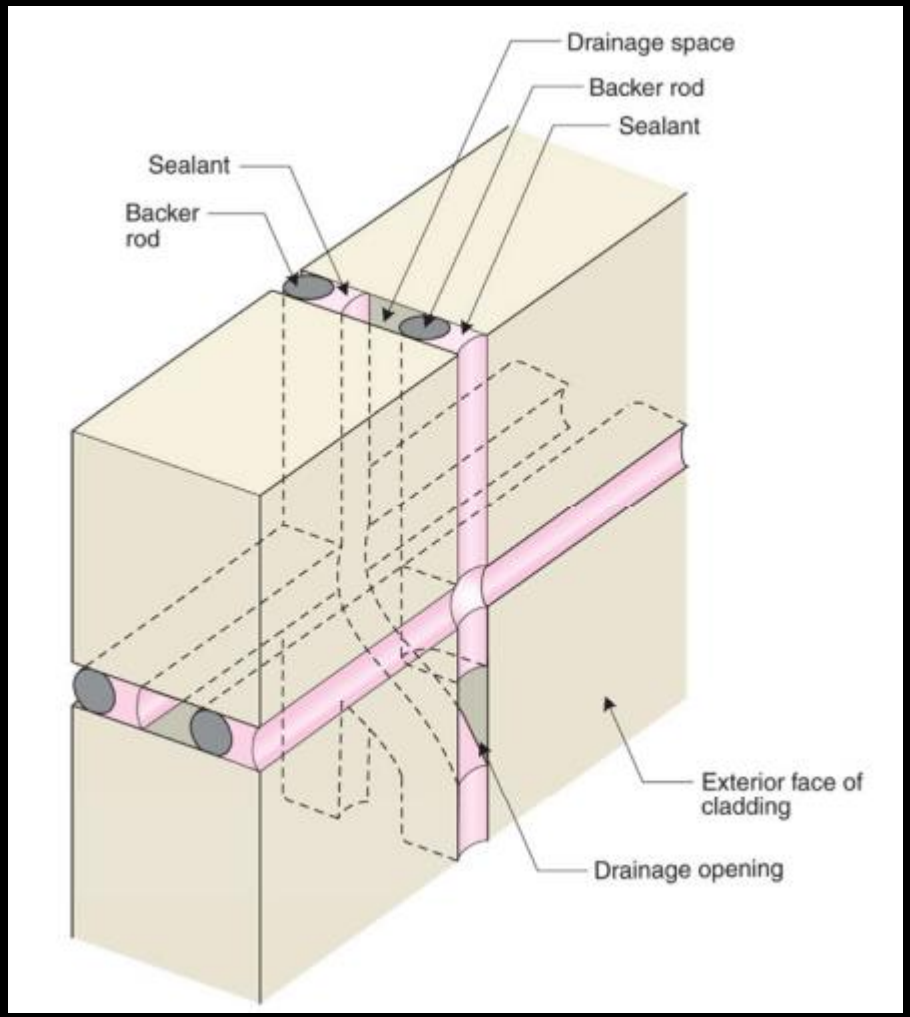

- Air Control
- Water Control
- Vapour Control
- Thermal Control
- Durability
- Maintainability

# 5.2 Panel Design / Detailing



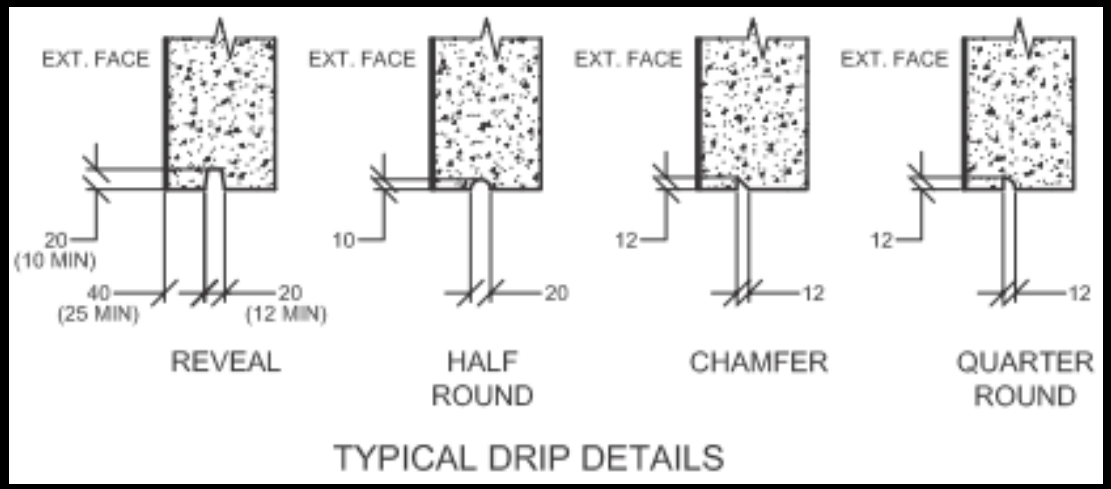

- Panelization
- Wythe Thickness/es
- Strength - Reinforcing
- Insulation Thickness
- Edge / Reveal Treatment
- Connection Hardware
- Handling Hardware

# 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

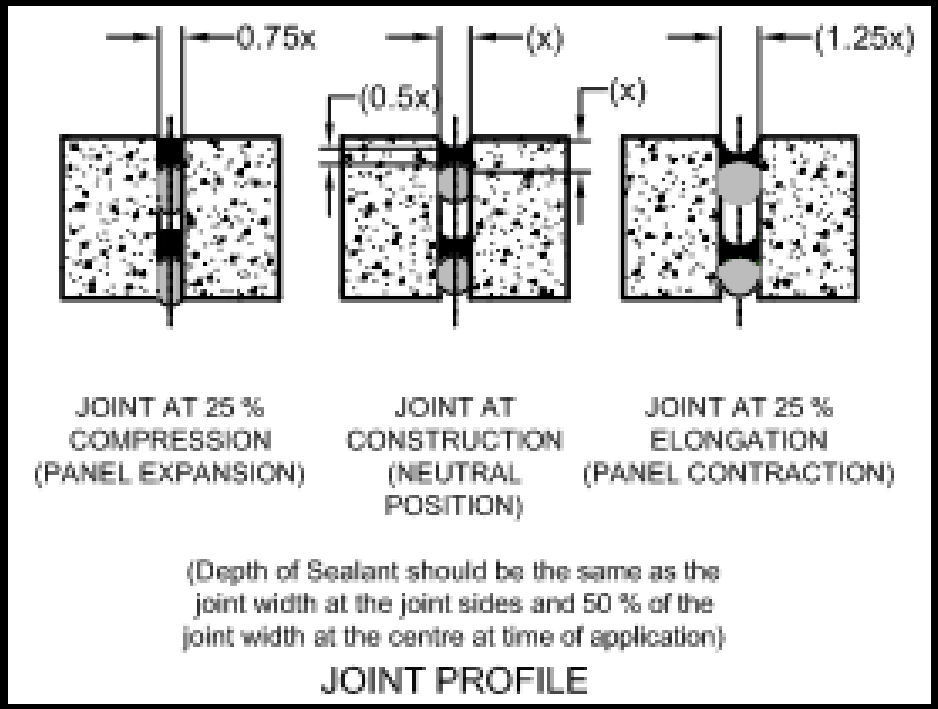
# Panel Drip Treatment



TYPICAL DRIP DETAILS

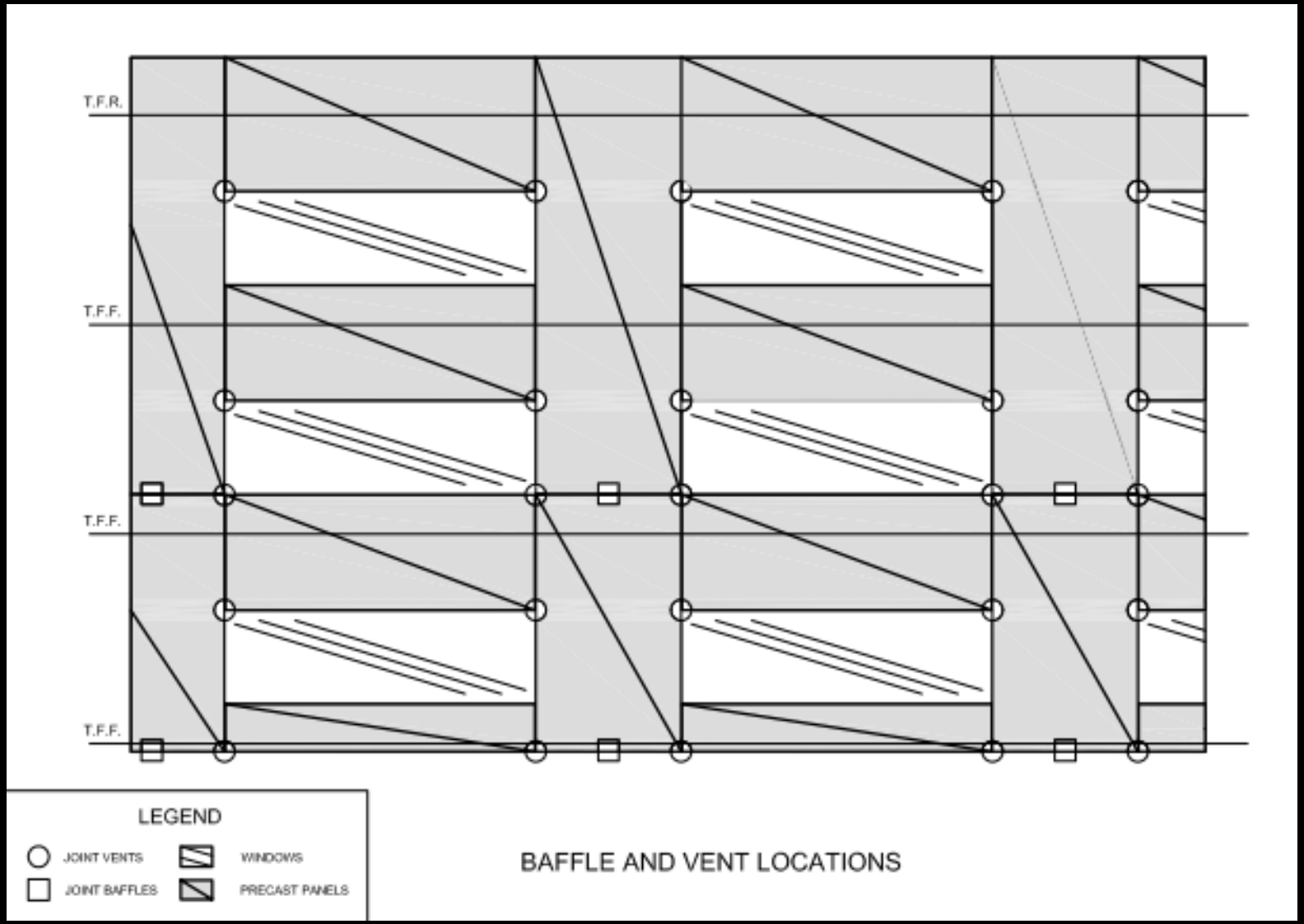
- Required on Bottom Edges
- Typical Shapes
- Vertical Face
- Minimum Sizes
- Minimum Setbacks from Face

# 5.4 Joint Considerations




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

# Vent and Baffle Locations



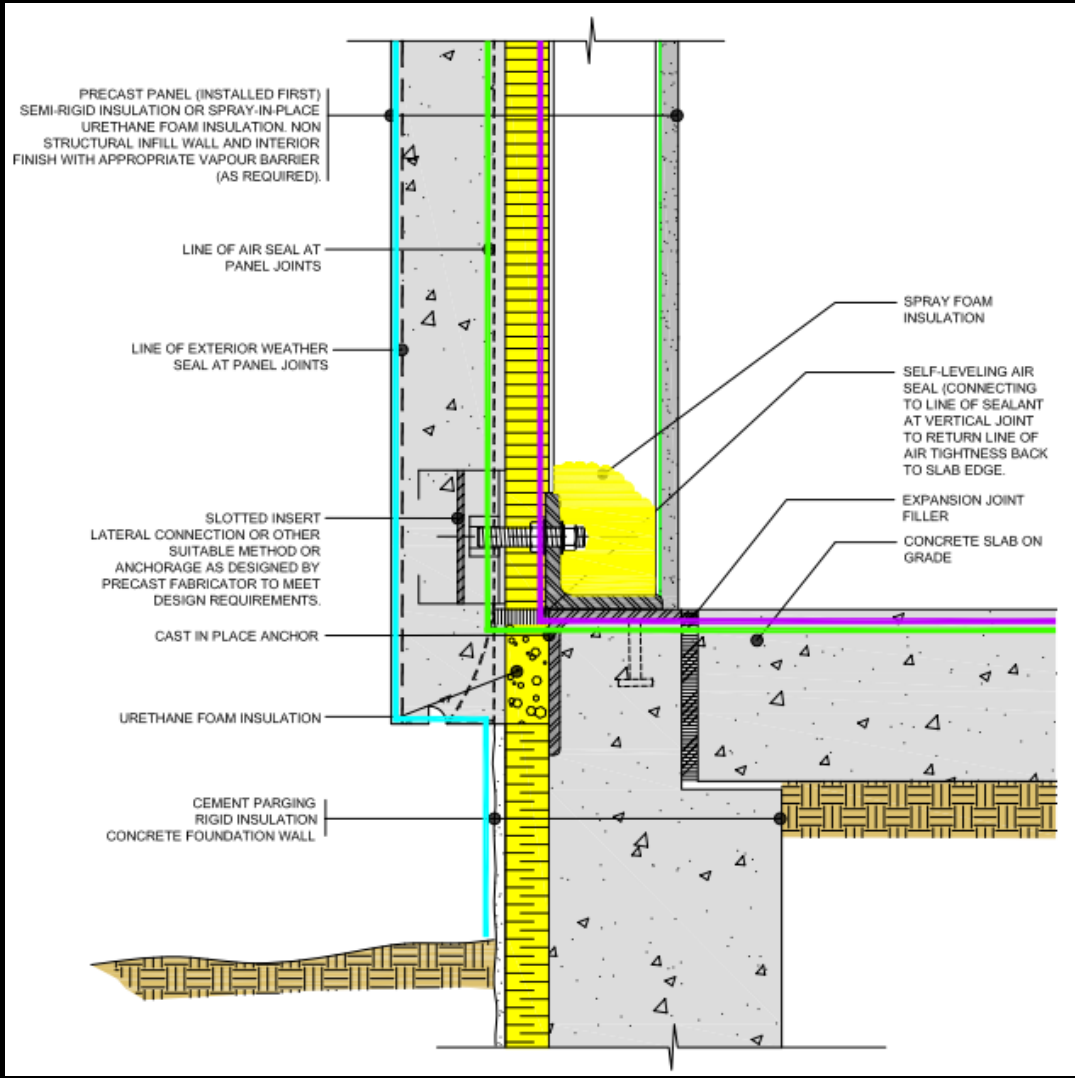
# 5.5 Sealant Selection / Testing

- 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

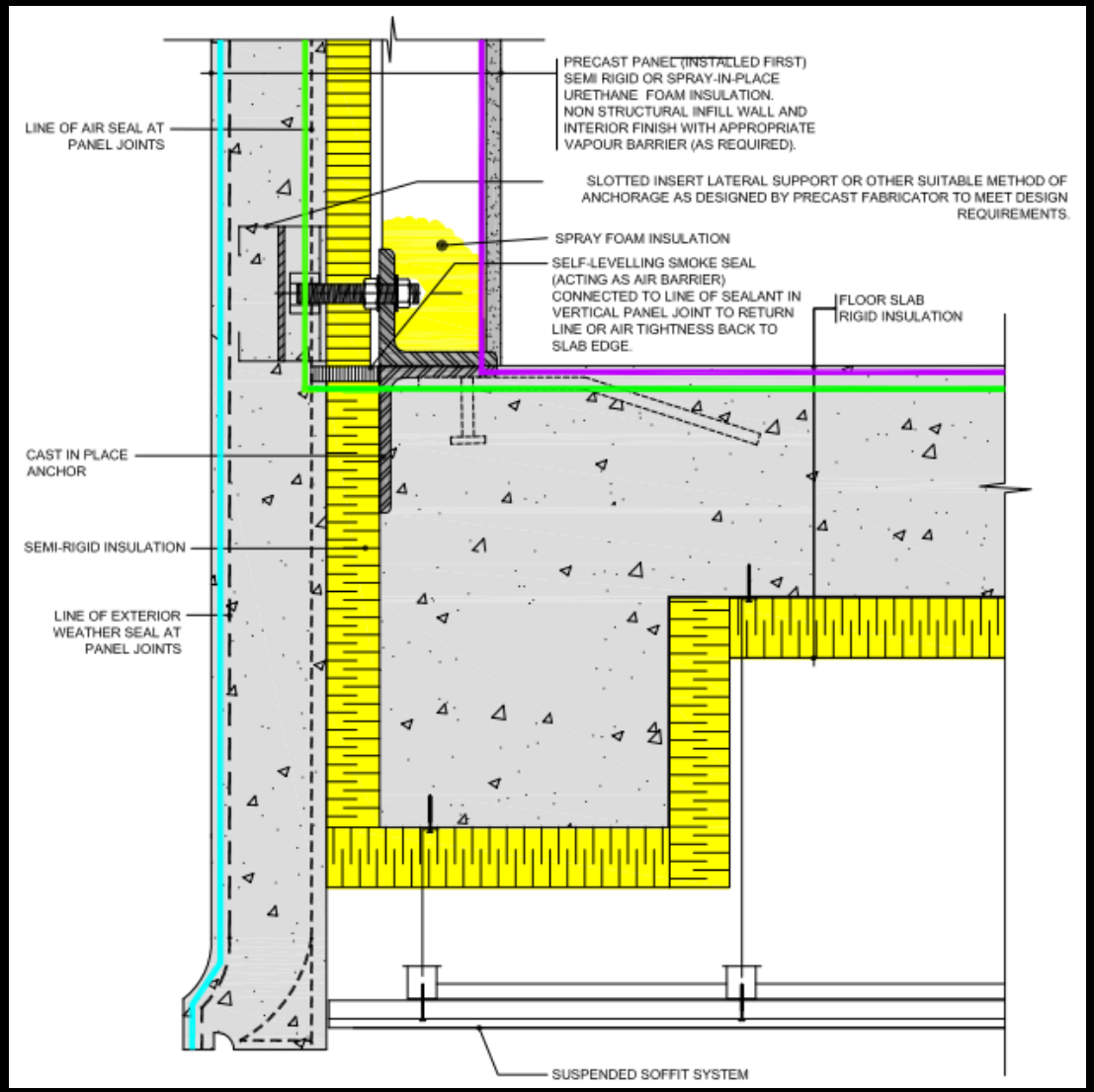
# 6.0 Sample Details



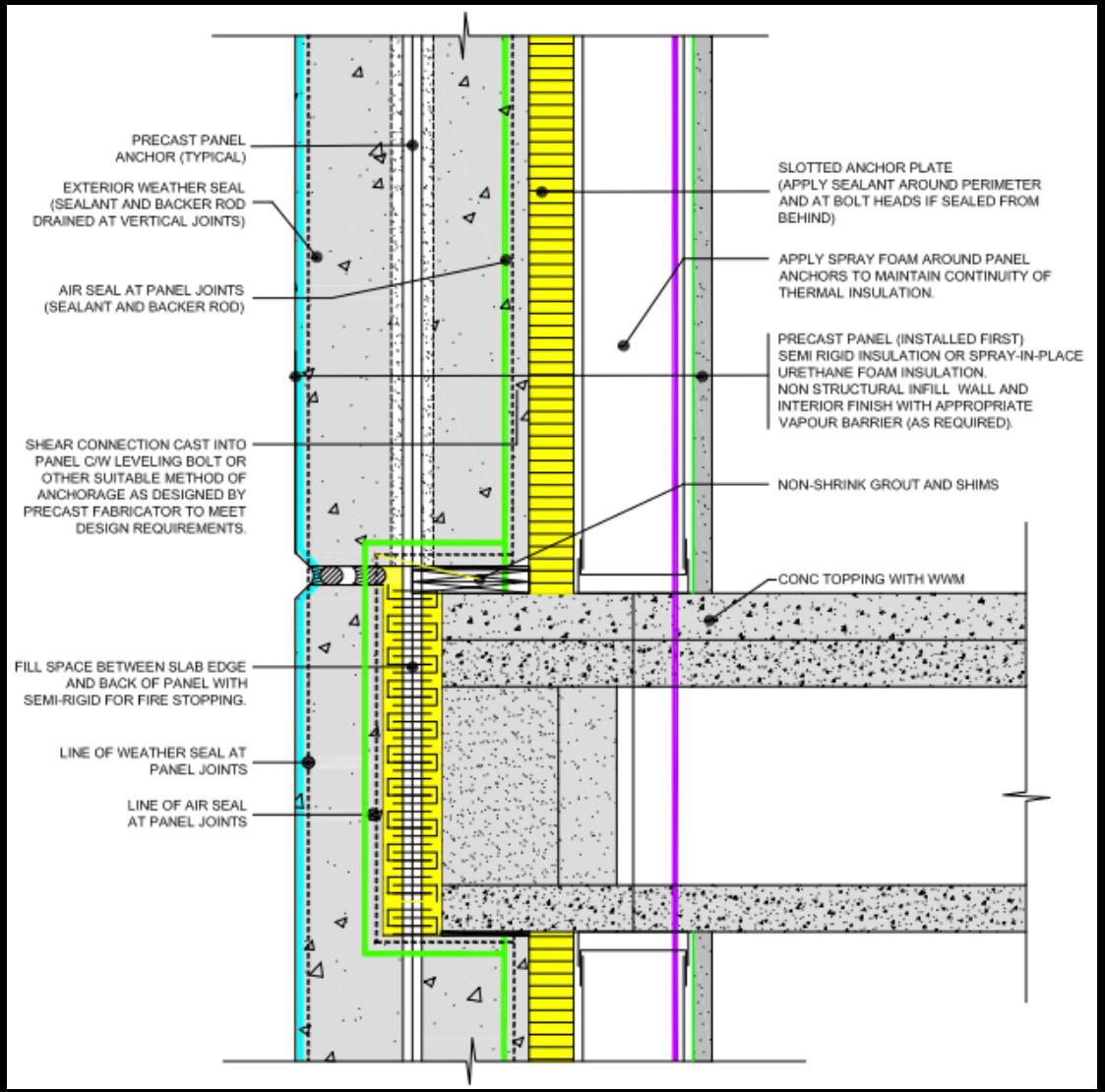

- Tie Ins with Other Materials
- Continuity
- Constructability
- Repairability

# Details – Single Wythe

## At Soffit



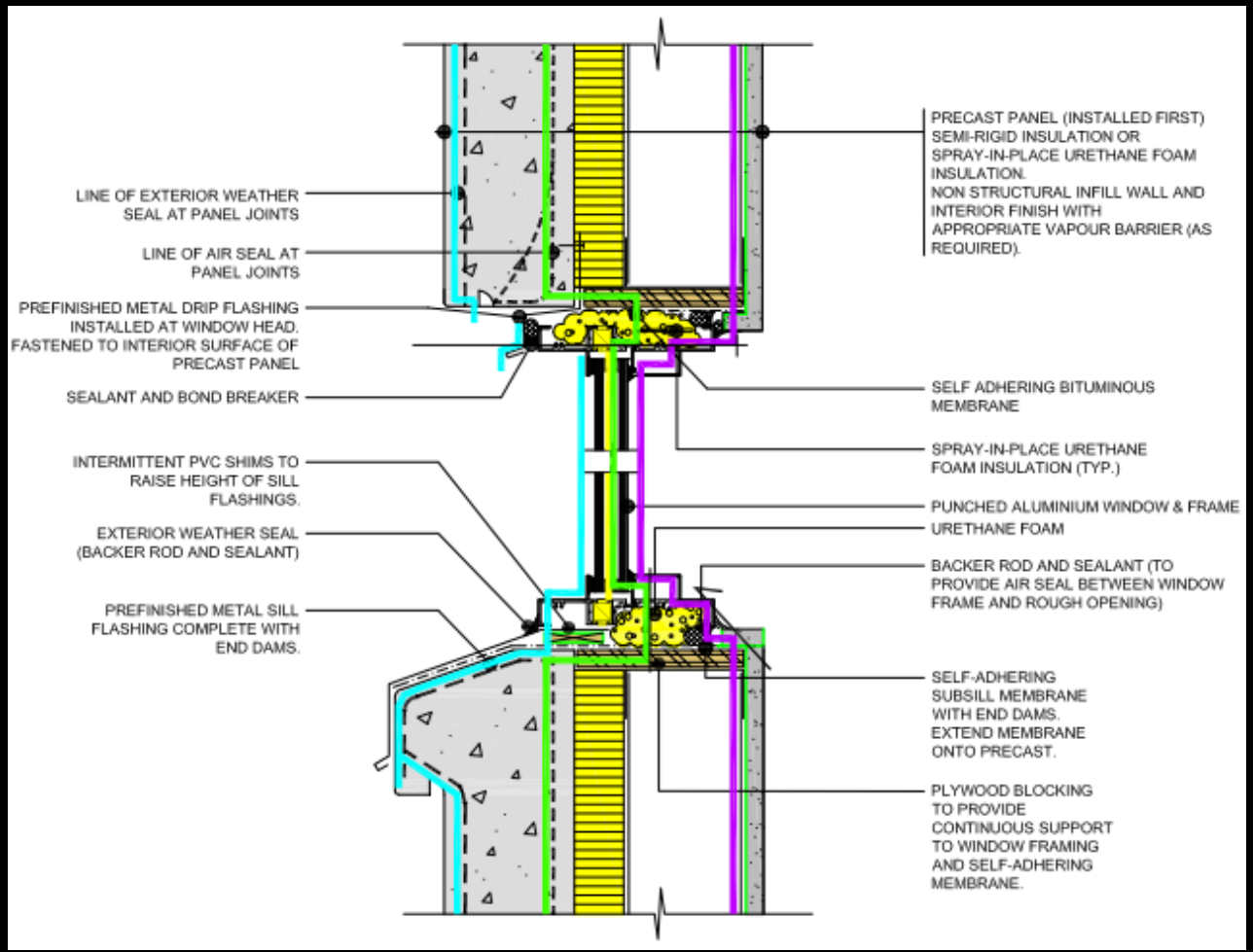
# Details – Single Wythe

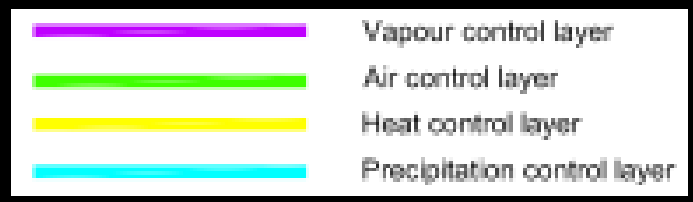



## Load Bearing (Hollow Core)

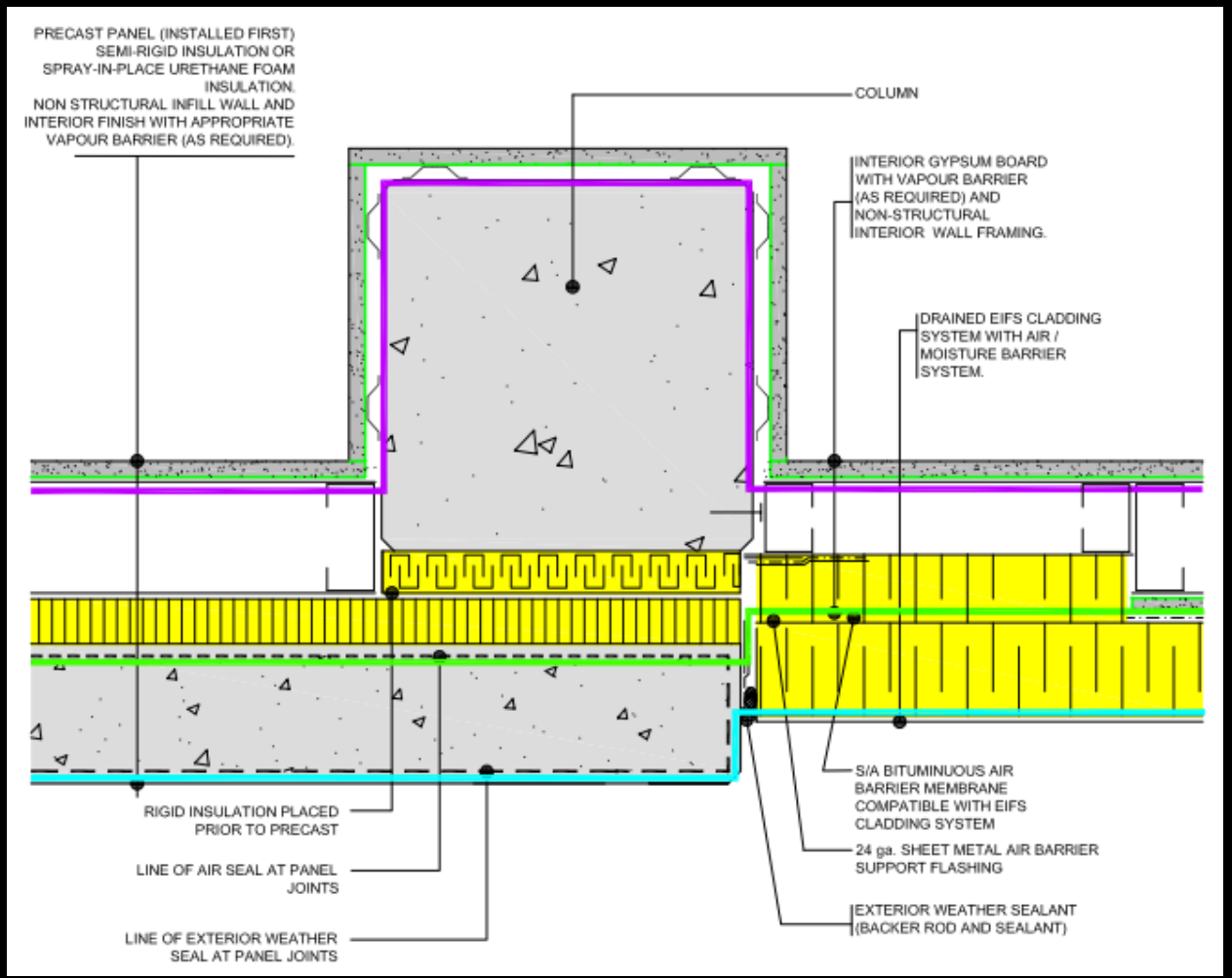
# Details – Single Wythe

## At Window

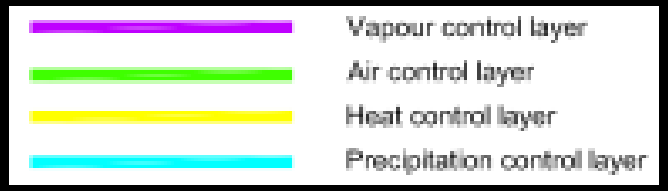


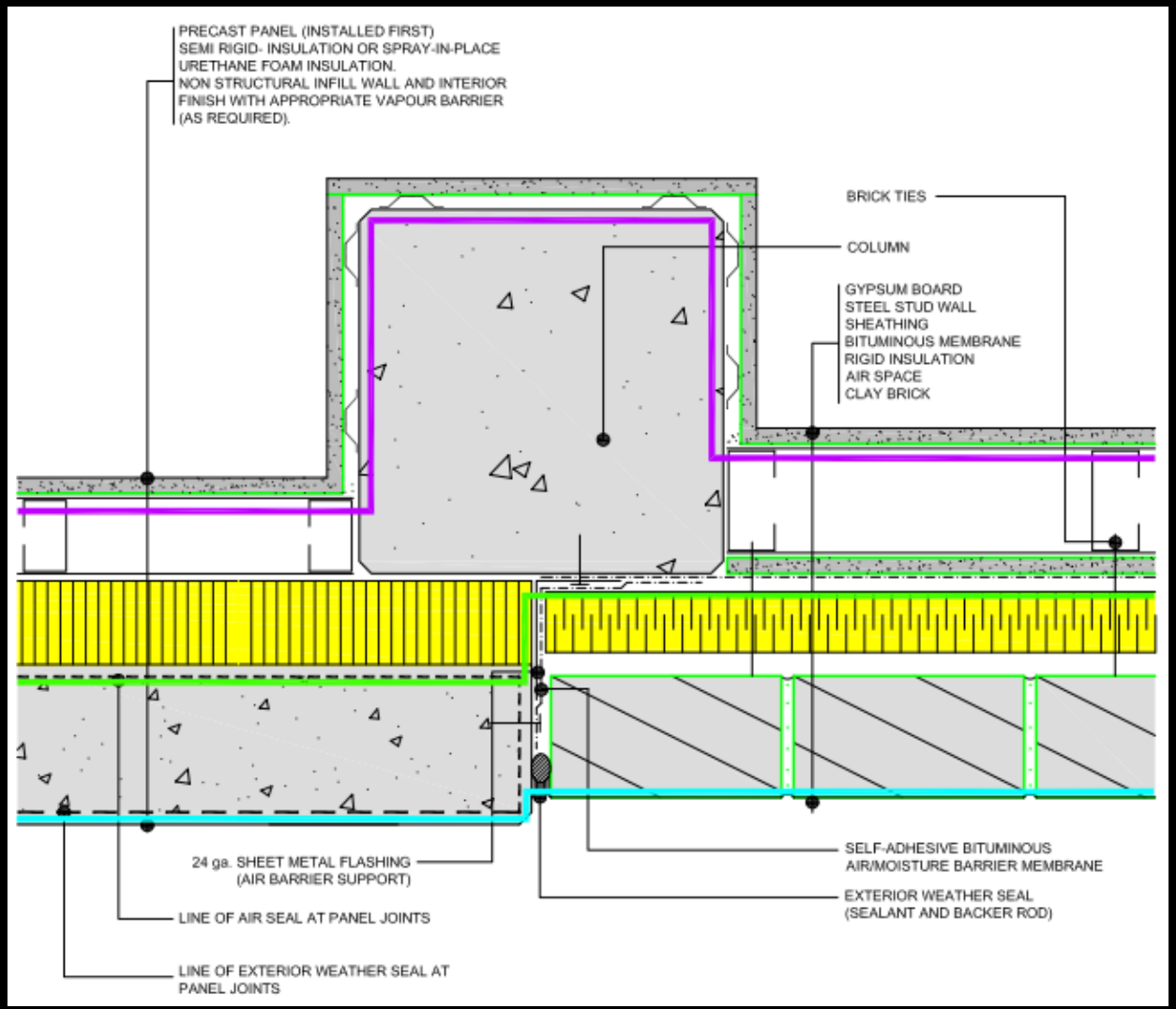
# Details – Single Wythe



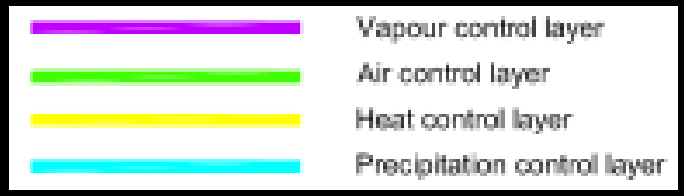

## Transitions To EIFS



# Details – Single Wythe

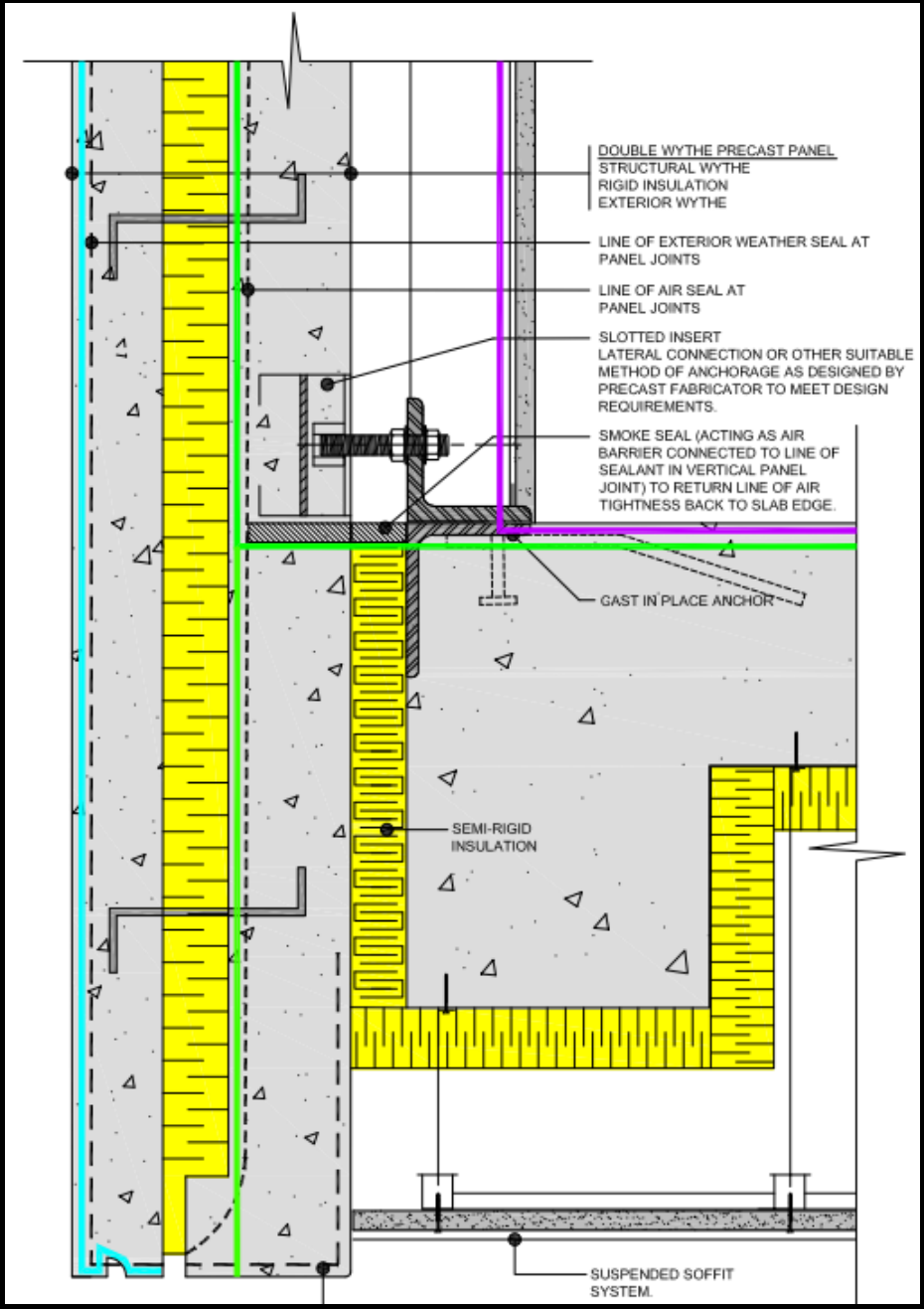



## Transitions (To Brick)



# Details – Double Wythe

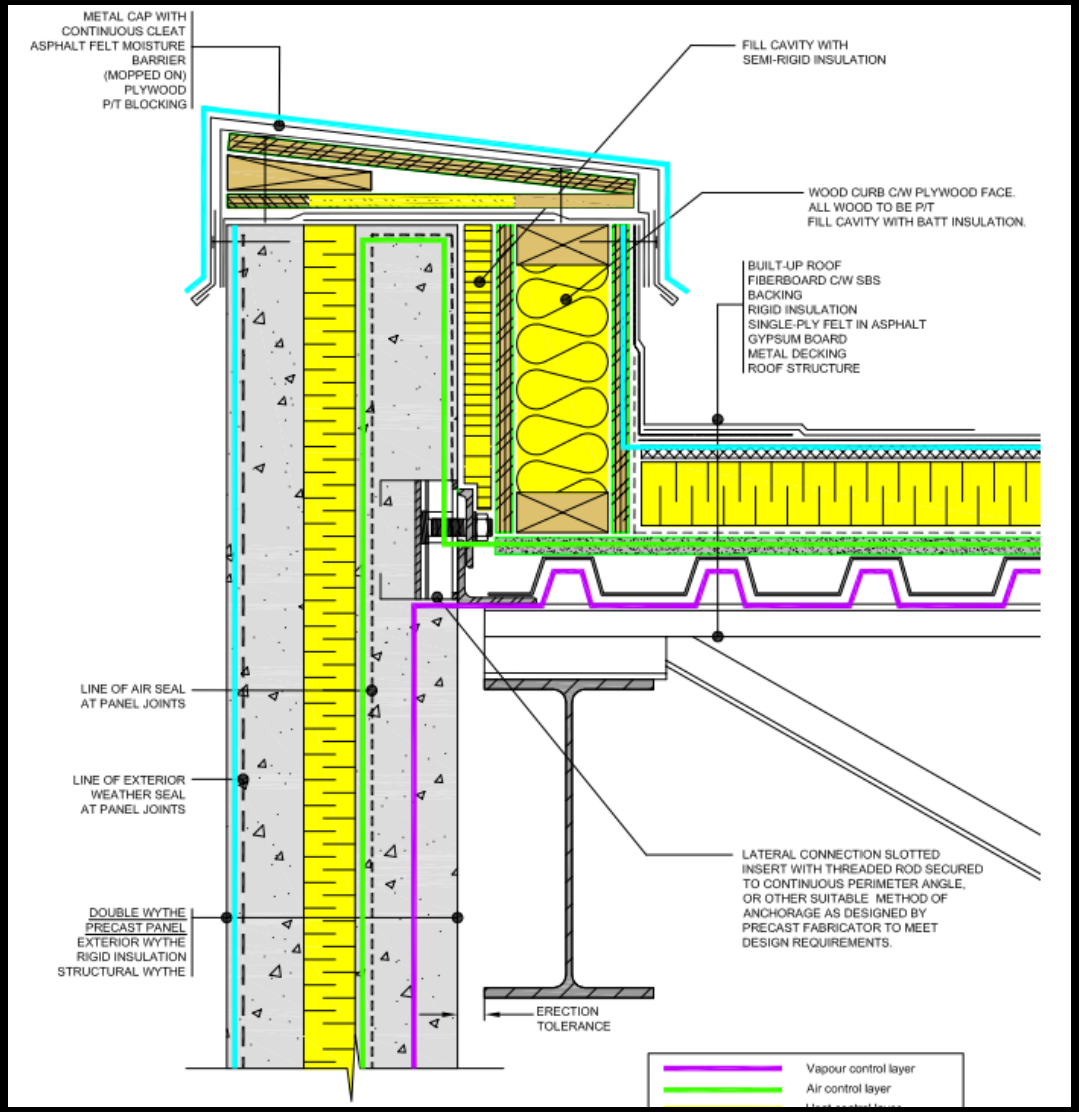
## At Soffit

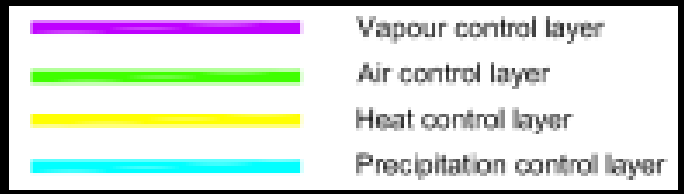



Vapour control layer
Air control layer
Heat control layer
Precipitation control layer

# Details – Double Wythe

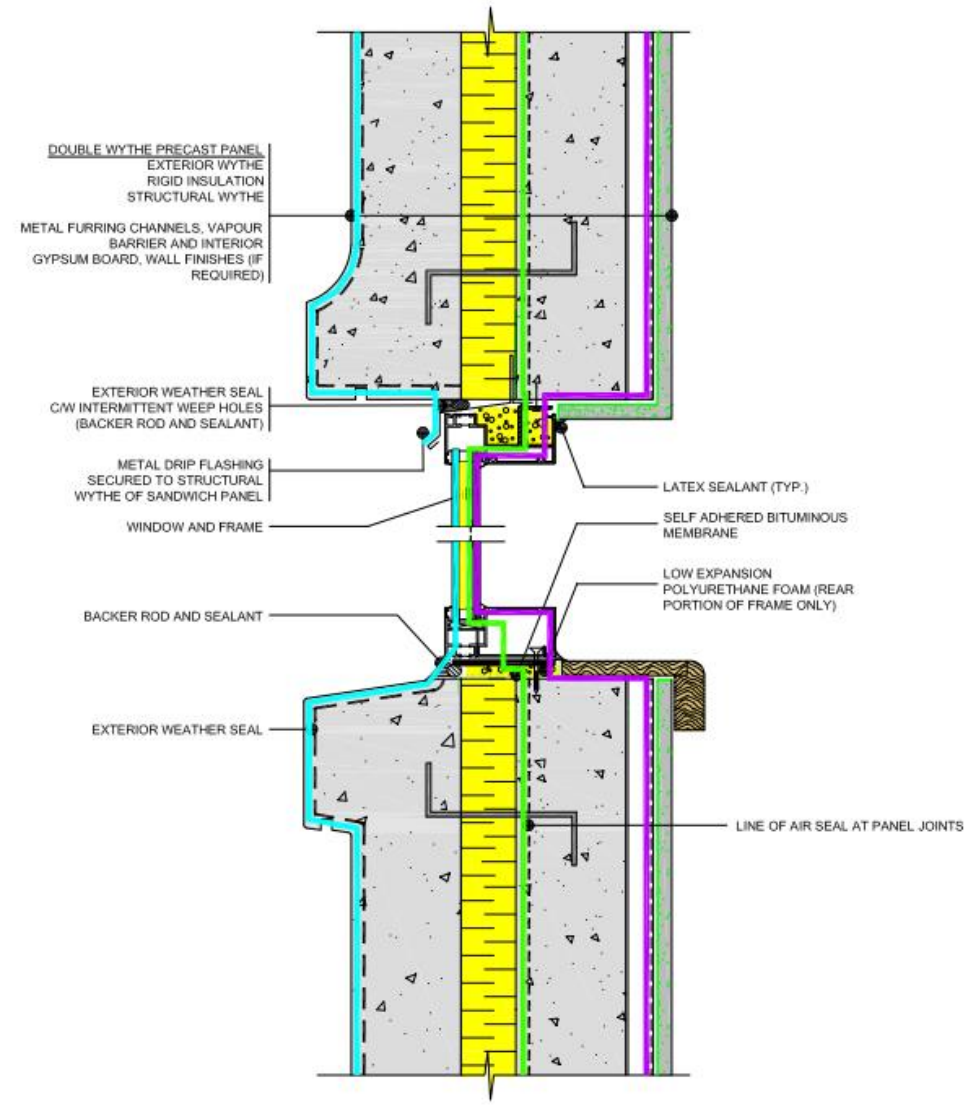
## At Parapet



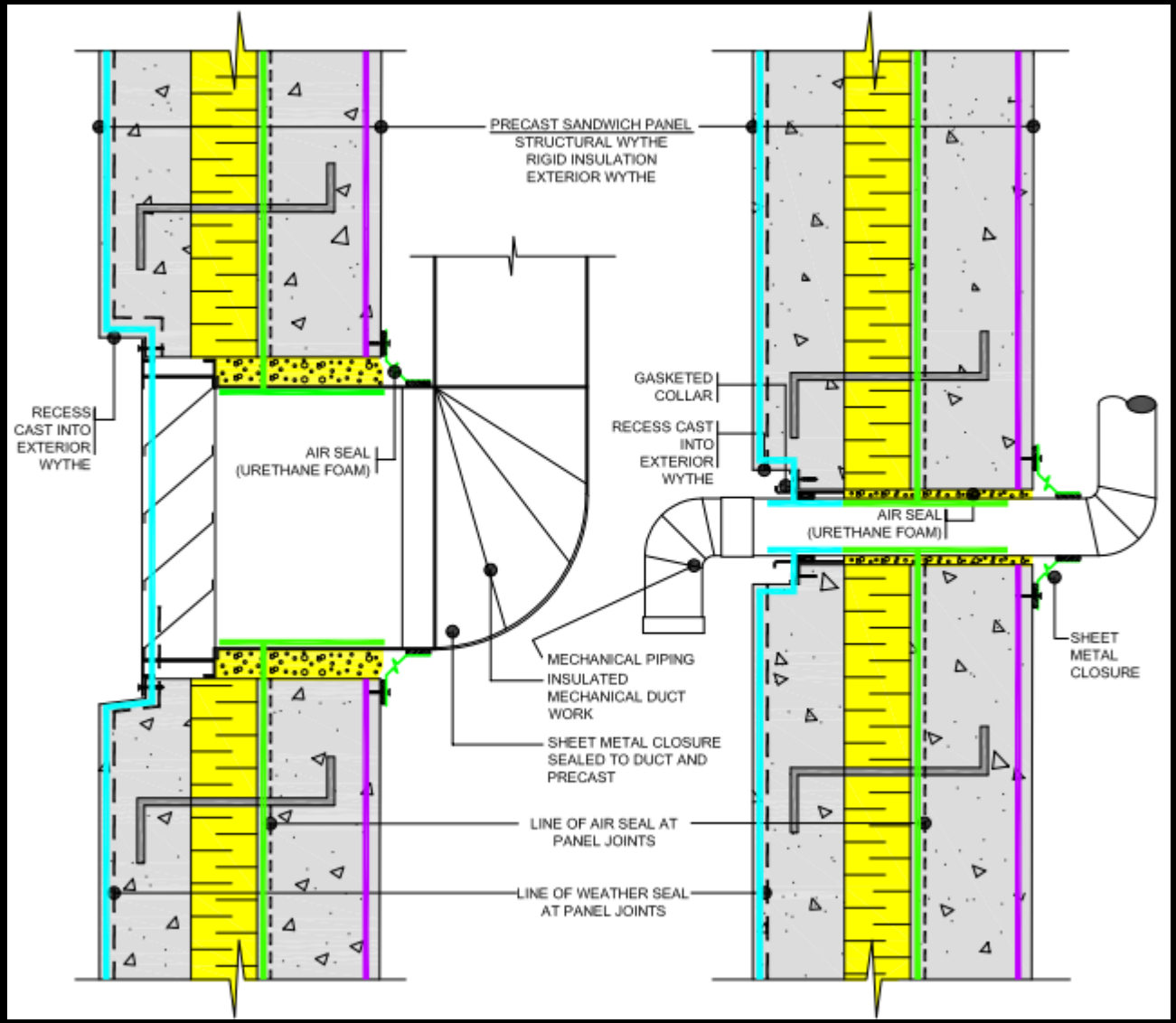



# Details – Double Wythe

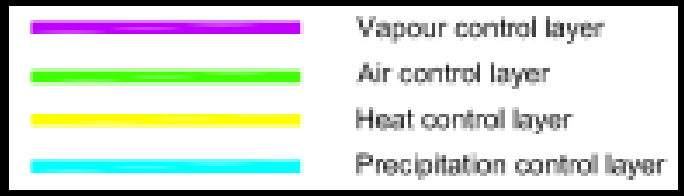
## At Windows



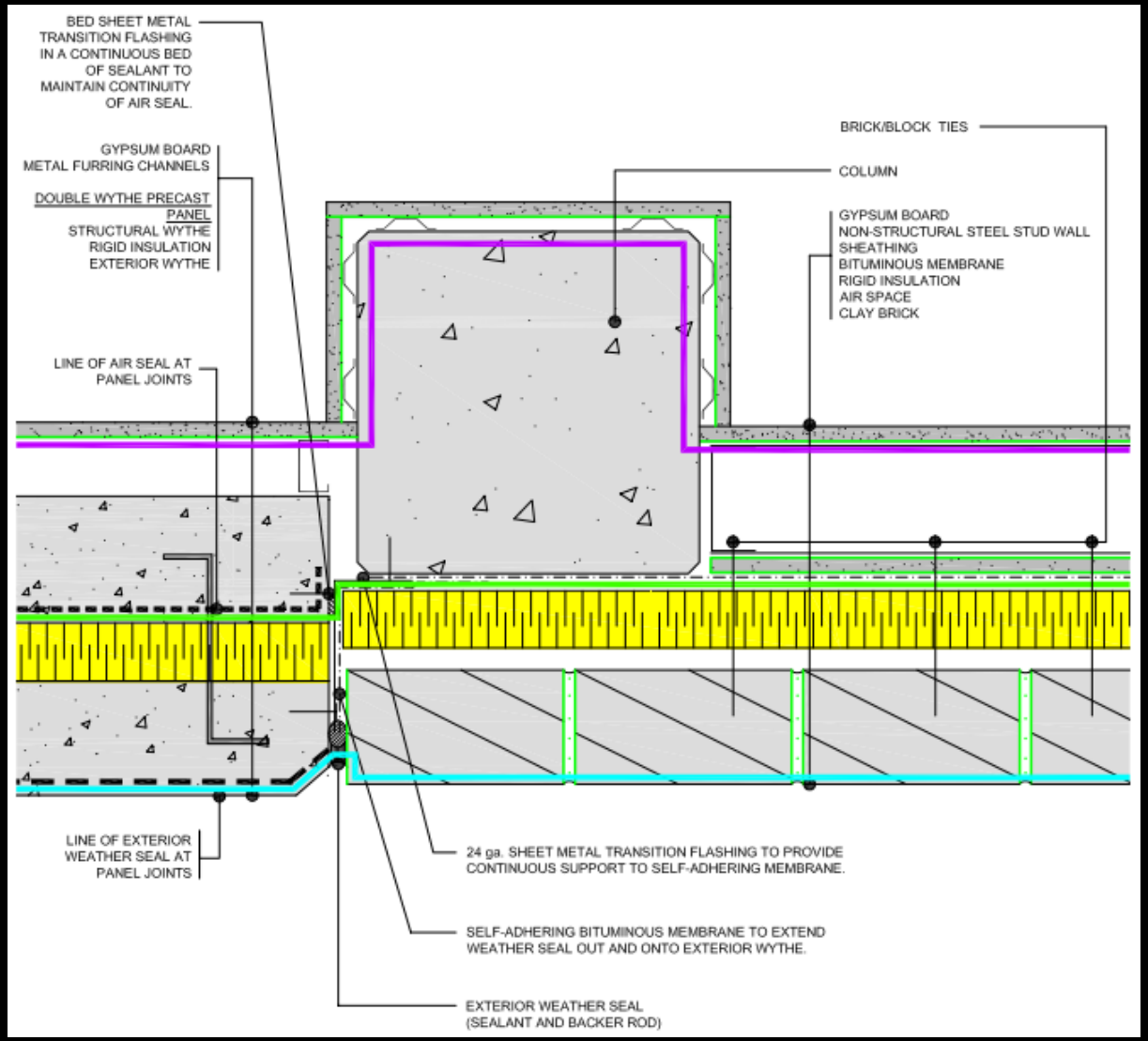
# Details – Double Wythe



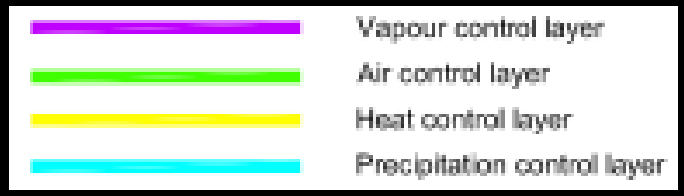

## For Mechanical



# Details - Double Wythe




## Transitions (To Brick)



# 7.0 Construction

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

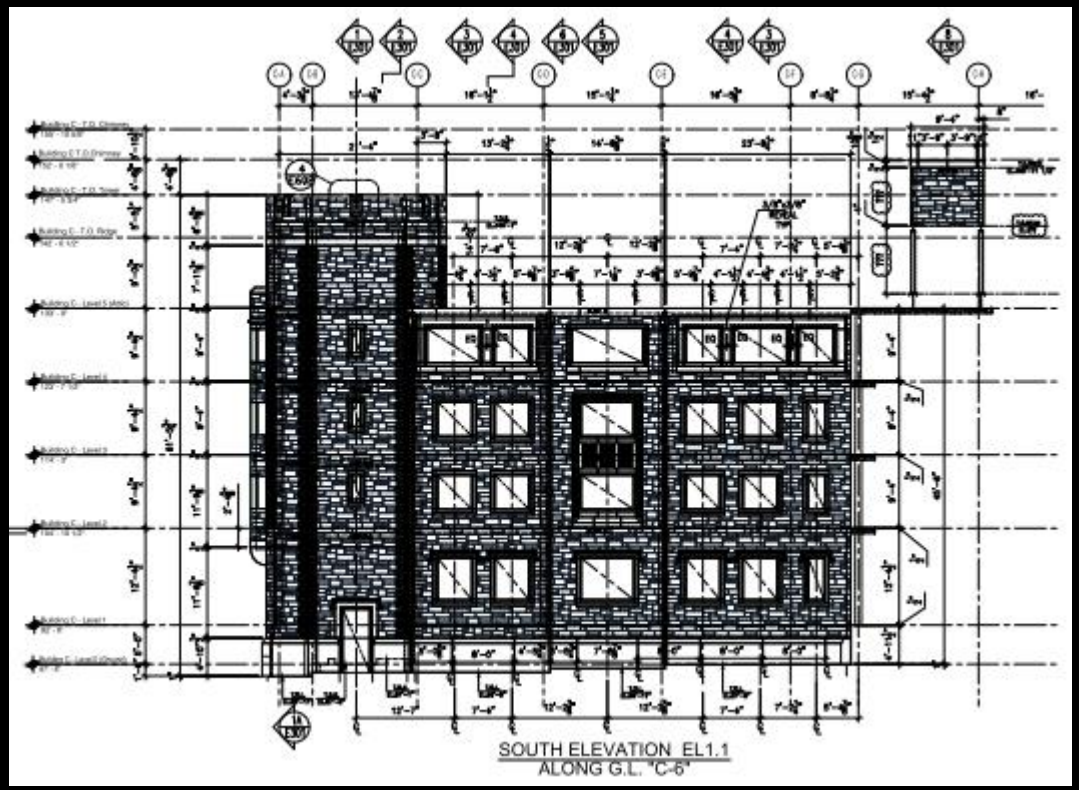
# 7.1 Design

- 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

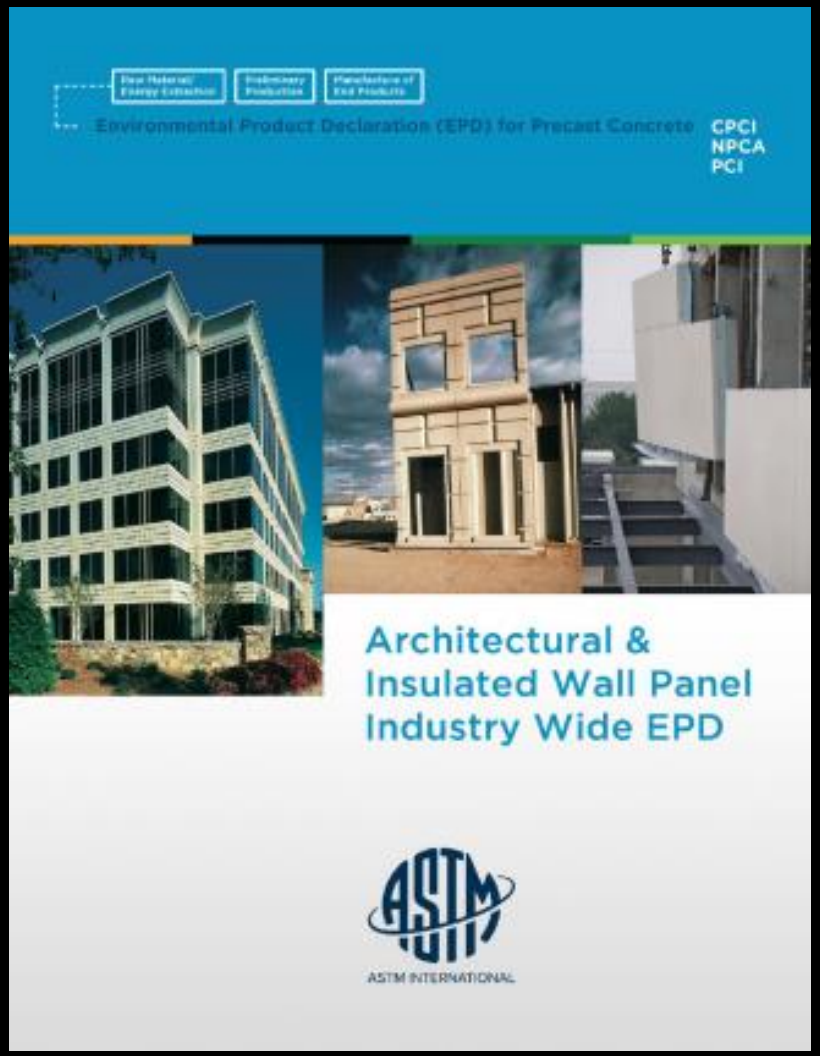
# 7.4 Samples

- **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

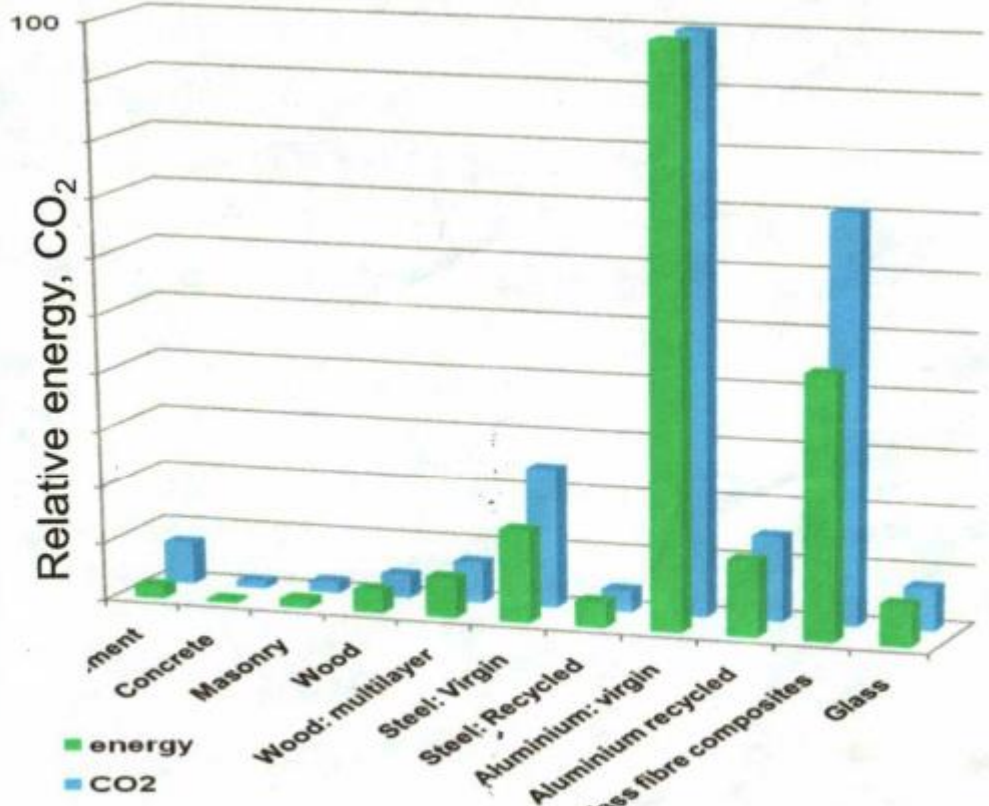
# 7.6 Sustainability and LEED




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

# Environmental Footprint of Precast

| 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