Architectural Precast Concrete Walls – Best Practice Guide

Presented by:
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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
- Member do 85% of Precast Produced in Canada

CPCI does
- Funds Precast Research
- Creates Precast Publications

CPCQA Certification
- Most Stringent of CSA and PCI
- 2 Day Audits by Engineers
- Name Changed to CPCQA from CPCI as of January 1, 2018
Architectural Precast Concrete Walls – Best Practice Guide

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
Architectural Precast Concrete Walls – Best Practice Guide

Single Wythe

- Outer sealant on backer rod
- Outer wool used is preferred but horizontal is acceptable
- Inner joint on backer rod continuous for water and air control continuity
- Outer seal chamfered at vertical joints

Note: Precast concrete is the water and air control layer between joints.

- Panel connection cast into panel with leveling shims; fill with spray foam to control convection of air
- Smoke seal (air seal) and firestop
- Fill space between slab edge and back or panel with mineral fiber firestop
- Line of outer sealant at panel joints as rainscreen and finish
- Line of inner sealant at joint: air seal and drainage plane

- Structural columns and walls should be held back from slab edge to allow for installation of air and thermal control layers.
Double Wythe Insulated

- Precast panel (installed first)
- Steel alignment plate completely sealed from interior air by spray foam
- Gypsum lath
- Steel stud
- Ensure firestop continuity at vertical joints
- Cast-in-place anchor

Notes:
- Outer sealant on backer rod
- Continuous 2-inch horizontal is acceptable
- Inner sealant on backer rod
- Water and air control continuity
- Outer seal drained at vertical joints
- Note: Precast concrete is the water and air control layer between joints
- Line of outer sealant at panel joints
- Line of inner sealant at panel joints
- Smoke seal and firestop as required

Structural columns and walls should be tied back from slab edge to allow for installation of connections.
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

LEGEND
△ LOAD BEARING
● LATERAL

CENTRELINE OF COLUMN LINE

T.R.D.
WINDOW
WINDOW

T.F.F.
WINDOW
WINDOW

T.F.F.
WINDOW
WINDOW

ELEVATION

VERTICAL SECTION (TWO-STOREY COLUMNS)
VERTICAL SECTION (THROUGH SPANDRELS)

HORIZONTAL SECTION (AT FLOOR LEVEL)
HORIZONTAL SECTION (AT WINDOWS)

COLUMN COVERS AND SPANDRELS
Horizontal Panels with Column Covers
Spandrel Panels

LEGEND

△ LOAD-BEARING

○ LATERAL

CENTRELINE OF COLUMN LINE

WINDOW

ELEVATION

HORIZONTAL SECTION (AT FLOOR LEVEL)

VERTICAL SECTION (THROUGH SPANDBRELS)

SPANDBRELS
Spandrel Panels
Punched Window Panels

SINGLE-STOREY PUNCHED WINDOW UNITS

LEGEND
△ LOAD-BEARING
● LATERAL

CENTRELINE OF COLUMN LINE

ELEVATION

HORIZONTAL SECTION (AT FLOOR LEVEL)
HORIZONTAL SECTION (AT WINDOWS)
VERTICAL SECTION (THROUGH WINDOWS)
VERTICAL SECTION (AT COLUMN LINES)
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

Aurora Municipal Justice Center
Aurora, CO
Architect: Skidmore, Owings & Merrill
Aesthetics - Finish

- **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

Radial Wall Form

Column 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
- Joint Detailing
- 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

- Required on all exposed bottom edges
- Typical shapes
- Must have 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

LEGEND
- Vent
- Baffle
- Window

BAFFLE AND VENT LOCATIONS
5.5 Sealant Selection / Testing

• Three Main Types
  – Polyurethane
  – Silicone
  – Hybrid

• Check Dimensions of Profile

• Verify with 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
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

<table>
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<tr>
<th>Material</th>
<th>MJ/kg</th>
<th>kgCO₂/kg</th>
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<tbody>
<tr>
<td>Cement</td>
<td>4.6</td>
<td>0.83</td>
</tr>
<tr>
<td>Concrete</td>
<td>0.95</td>
<td>0.13</td>
</tr>
<tr>
<td>Masonry</td>
<td>3.0</td>
<td>0.22</td>
</tr>
<tr>
<td>Wood</td>
<td>8.5</td>
<td>0.46</td>
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<tr>
<td>Wood: multilayer</td>
<td>15</td>
<td>0.61</td>
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<tr>
<td>Steel: Virgin</td>
<td>35</td>
<td>2.8</td>
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<tr>
<td>Steel: Recycled</td>
<td>9.5</td>
<td>0.43</td>
</tr>
<tr>
<td>Aluminium: virgin</td>
<td>218</td>
<td>11.46</td>
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<tr>
<td>Aluminium recycled</td>
<td>28.8</td>
<td>1.69</td>
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<tr>
<td>Glass fibre composites</td>
<td>100</td>
<td>8.1</td>
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<tr>
<td>Glass</td>
<td>15.7</td>
<td>0.65</td>
</tr>
</tbody>
</table>

ICE version 1.6a
Hammond G.P. and Jones C.J
2008 Proc Instn Civil Engineers
www.bath.ac.uk/mec1-eng/serf/embodied/
# High Performance Attributes and Benefits of Precast

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

Versatile  |  Efficient  |  Resilient

Precast Concrete

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