Thank you for attending the presentation: High Performing Precast Concrete Building Enclosures

The following includes the presentation slides as well as some additional resources
High Performance Facilities

The ABC’s of Accelerated Building Construction

Presented by:
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M. E. Hachborn Engineering Limited
Agenda:

1. High performance attributes ...and why we need them
2. Precast ‘Kit of Parts’ - structural options
3. Process – prefabrication of precast elements
   • Structural / architectural components
   • Aesthetic features – color, form, texture
   • Modular construction
4. Residential facility applications – case studies
ABC is a paradigm shift in project planning, design, procurement, construction and commissioning that seeks to gain the benefits of minimizing the impact of on-site construction by setting pre-construction processes and systems to a higher priority.
This ABC ‘shift’ allows for the realization of intrinsic benefits such as:

• Lowering capital costs,
• Shortening overall timelines,
• Improving site safety and security,
• Gains in project quality,
• Enhancing project durability,
• Offering more opportunity to incorporate new technologies into the project,
• Reducing long-term operational costs,
• Limiting social impact costs, AND
• Limiting environmental impacts in the short and long term.
ABC improves:

- Complete design integration,
- Site constructability,
- Site security during construction,
- Total project delivery time,
- Project-zone safety for workers and the public alike,
- Project durability, AND
- Access to leading technologies for buildings.
What is Resiliency

This term is defined by the globalization-focused Rockefeller Foundation as: making people, communities, and systems better prepared to withstand catastrophic events—both natural and manmade—and able to bounce back more quickly and emerge stronger from these shocks and stresses.

Calgary, AB: In the aftermath of the epic 2013 flood that displaced 100,000 Calgarians, concrete structures like the Calgary Center Street Bridge were proven to be the most resilient. Architect: John F. Green Photo: Ryan Quan [Flickr]

Otsuchi, Japan: A shipwrecked ferry rests atop a concrete building in the aftermath of the devastating Tohoku Tsunami of March 2011. Photo: Hiroto Nomoto
Resilient – Tornado resistance
Impact / storm resistance – wind-borne flying objects (tornado, hurricane, etc.)
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Precast Components - Basic building blocks – “Kit of parts”

A. Load-bearing architectural spandrel
B. Exterior column
C. Double-tee or Hollowcore plank
D. Interior column
E. Inverted tee beam or composite beam
F. Shear wall
G. Stairs
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Precast components (custom vs. commodity products)

**Architectural Precast:**
- Architectural Wall Panels
- Double Wythe Insulated Wall Panels
- Radial Panels
- Spandrel Panels
- Architectural Cladding
- Column Covers
- Prison Cells
- Modular Units

**Structural Precast/Prestressed:**
- Hollowcore Floor & Roof Planks
- Double Tees
- Structural Wall Panels
- Columns
- Beams
- Spandrel Panels
- Horizontal Lite Walls
- Raker Beams
- Bleachers / Tread & Risers
- Bridge Girders
- Piling
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Context:

‘Total’ Precast Concrete Structures:

Solutions which integrate architectural and structural precast concrete components - to create the buildings structural frame and panelized façade or enclosure …

(sometimes in the same components).
Using precast concrete components together as a complete structural system creates a design in which the whole is greater than the sum of the parts.

For example, combining precast prestressed hollowcore plank or double tees with precast beams and columns creates a durable, fire-resistant structure that is quick to erect and cost efficient due to the compressed construction schedule.

RESOURCE:
PCI Design Handbook
All lateral loads are transferred to a moment-resisting frame that ties beams and columns together with “rigid” connections. The need for shear walls is eliminated.
Lateral loads are transmitted by floor diaphragms to a structural core of precast shear walls. The shear wall can be tied together vertically and at corners to form a structural tube that cantilevers from the foundation.
In general, an exterior shear wall system permits greater design flexibility because it eliminates the need for a structural core.

By combining gravity load bearing function with lateral load resistance, the exterior shear wall system is also, in general, more economical.
Double tees provide excellent roof and flooring units, spanning considerable distances and providing quick erection to close in a structure more quickly. They can expand a designer’s options for floor layouts by eliminating interior columns and offering excellent fire resistance and durability.
Prestressed hollowcore plank

Hollowcore planks can span long distances and be erected quickly, helping to finish floors so interior trades can begin work faster. They provide acoustical and impact dampening.

They also offer strong fire resistance, especially when used together with an all-precast framing system.
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Integrated precast components
Precast Fabrication = prefabrication

Precast/prestressed concrete products are plant produced architectural and structural building components.

They are manufactured in quality controlled, CPCQA - Certified facilities where critical variables including mix design, consolidation, weather conditions, finishes and tolerances can be closely monitored and controlled.

This allows for safe, accelerated construction with high-finish quality which exceeds tilt-up or concrete cast-in-place at the job-site.

Buzzwords:  
Prefabrication  
Offsite Construction
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Prefabrication – precast concrete plants

- Storage yard
- Raw materials storage
- Manufacturing facility (long line)
- Batch plant

Precast Plants are manufacturing facilities
Precast (on-site) Batch Plant

Precast Concrete – batched of durable, high-strength concrete - water, sand, cement, aggregates and admixtures, mixed in controlled factory conditions to required design strengths - typically 35+ MPa or 5,000+ PSI.
In prestressed, precast concrete components, high-tensile strength (1860 MPa or 270 ksi) steel strands are pretensioned and cast into concrete components.
Prestressed, long-line, double tee form

The prestressed component is created by pulling the steel strand along the length of a bed or form and locking it into place at the fixed abutment end.

Then the individual strands are elongated or stressed by hydraulic jacks to achieve the tension level required for the design specifications.
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Hollow Core (extruded)
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Structural beams ...
Wall panels - steel forms and custom molds

Steel wall panel form

Custom wood wall panel form
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Wall panels – three basic types

- **Solid**
- **Thin-shell**
- **Double Wythe Insulated Wall Panel**

- Load bearing or non-load bearing
- Versatile - available in essentially any shape and finish
- **Rain, air, and vapor barrier** (vs. rain screen)

Architectural Surface
Exterior Wythe
Interior Wythe = Thermal Mass
Rigid Insulation (Continuous Insulation)
Enclosure systems

Thermally efficient enclosures provide:

- Protection against moisture
- Continuous insulation, air and vapor barriers
- Similar to curtain wall – perfect barrier

<table>
<thead>
<tr>
<th>Material</th>
<th>Average leakage, cfm/ft² of surface at 0.3 in. H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid precast concrete wall</td>
<td>No measurable leakage</td>
</tr>
<tr>
<td>Extruded polystyrene insulation</td>
<td>No measurable leakage</td>
</tr>
<tr>
<td>½” fibreboard sheathing</td>
<td>0.31</td>
</tr>
<tr>
<td>Uncoated brick wall</td>
<td>0.31</td>
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<tr>
<td>Uncoated concrete block</td>
<td>0.41</td>
</tr>
<tr>
<td>1” expanded polystyrene</td>
<td>0.93</td>
</tr>
</tbody>
</table>
Thermal Mass Effect:

- Absorbs outside and inside heat and slowly releases
- Delays the onset of peak heating or cooling loads
- Reduces energy consumption and peak demand
- Enables downsized HVAC systems and smaller first cost investment
- Reduces indoor temperature fluctuation to improve occupant comfort
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Double wythe insulated wall panels

Thermal efficient envelope system – for higher energy efficiency and achieve additional advantages.

These panels consist of a layer of precast that is poured into the form (architectural surface down in form), after which the insulation is placed and another layer of concrete is added. (Entire building envelope in one panel)
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Double wythe insulated wall panels
Double wythe insulated wall panels
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Double wythe insulated wall panels

- Thermal efficient wall system
- Single trade, reduced materials + risk + time
- Barrier wall, fully sealed (two stage joint)
- Continuous insulation, air & vapor barriers

Exterior / architectural surface

Interior surface

Rigid insulation

Edge-to-edge (CI)

Interior surface

Ready for painting
Aesthetic versatility:

Through on-going enhancements to the fabricating processes, architectural precast can be produced in almost any Color, Form or Texture.
Composed of a unique concrete mixture(s) with certain physical and structural properties:

- Cement - white and/or gray
- Aggregates / Sand - define color, texture
- Pigments - if required to augment color
- Water and chemical admixtures
Color: Applied Coatings (Stain)
Pick any color you want; there's virtually no limit.
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Color Texture with Stains and Form Liners
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Color & Texture with Stains and Form Liners used on the Interior
Molds - sculpture, form liner, lettering

Fig. 3.5.20 Recessed lettering.

NÇOIS

Close-up view of lettering on a precast concrete panel with right angle shoulders

Square shoulders of the V-recessed letter makes a sharp shadow, but the broken surface of the back causes an uneven shadow making the letter appear irregular.

Recessed letters with right angle shoulders and flat back stand out clearly, because the shadow cast by the outer angle against the flat back is strong and regular.

Centralia High School
Centralia, IL
Architect: FGM Architects/Engineers, Inc.
Form – custom column and radial wall panel molds
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SCAD Museum of Art - load-bearing, insulated precast building enclosure, historic adaptation...
Savannah, GA
Architect: Sottile & Sottile; Lord, Aeck & Sargent; Dawson Architects
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CENTRALIA HIGH SCHOOL
Form – custom wood & fiberglass molds

Key to economy is repetition
Aesthetic options for buildings are ever-changing as developers and owners compete to attract the public with distinguishing features.

Formliners and concrete colour stains can translate your designs into three dimensional building facades.
Form liners

*Fig. 3.5.11 Some of the available form liner patterns.*
Stone textured form liners

Natural stone expressions can be achieved with custom-molded, flexible elastomeric form liners that use actual stone as the master pattern. Once cured, the flexible form-liner pieces are placed into the precast mold. The resulting pieces are sandblasted or acid-etched to create a remarkable stone-like appearance.
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Unity Christian High School
Hudsonville, MI
Architect: GMB Architecture & Engineering
Artistic form liners

Kohl Center, Univ. of Wisconsin, Nichols-Johnson Pavilion
Madison, WI
Architect: HOK and Heinlein & Schrock (JV)
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Texture – clay product-faced (thin brick)

Jack Britt High School
Fayetteville (Cumberland County), NC
Architect: SFL+ A
Texture – clay product-faced (ceramic tile)
Texture – stone veneer-faced
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Dubiski Career and Technology High School
Grand Prairie ISD, TX
Architect: Corgan Associates Inc.

$45 million, 260,000 SF
59,425 SF - 288 pieces of precast insulated panels of varying sizes

Best School 2012 PCI Design Awards
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Texture – multiple finishes (double wythe insulated wall panel)

- Acid-etched finish
- Sand blast finish
- Retarder, exposed aggregate finish
- Thin brick veneer

Precast plant forming/finish exercise
w/ PCI Foundation sponsored Precast Design Studios
at UNC Charlotte and Clemson University.
Modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standards as conventionally built facilities – but in about half the time.

Modular Building Institute
Accelerated Building Construction (ABC)

Modular and prefabricated elements for construction are used to replace traditional, inefficient in-situ construction methods.

Modular and prefabricated elements address critical groups of activities that are either considered Fundamental or Comprehensive in nature.
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Accelerated Building Construction (ABC)

Habitat 67 MONTREAL, QC. - COMPLETED 1966 Habitat, the central feature of Canada’s Expo ‘67 World’s Fair, is well known for its “original, bold design, which showcased construction techniques unheard of at the time.” In 2009, Habitat was designated as an historic monument by the Quebec government. Total Precast Modular construction
Hilton Palacio del Rio Hotel, San Antonio, TX ...

ABC has history on its side.
Accelerated Building Construction (ABC)

The ABC process was touted by the Modular Building Institute (MBI) for this hotel built in San Antonio TX in 1968.

Only one short block from the convention center stands a 21-storey example of modular construction that has become a part of the historical landscape of San Antonio, as well as an early and ever-present example of the engineering feats modular construction can undertake.
The Hilton Palacio del Rio Hotel is proudly pointed out to visitors as a 'modular' hotel with a history worthy of landing it on the famed Riverwalk boat tour for review and discussion. This original story written in 1968 about the project upon its construction. Interestingly, the piece is timeless in that the application could happen just as easily today.
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Recent (ABC) Projects

Toronto South Detention Centre
Recent (ABC) Projects

Toronto South Detention Centre

Modular precast concrete jail cells before stacking

Cells were delivered with beds, desks, and sinks and toilets pre-installed
Recent (ABC) Projects

Innovationen Tower, a 125-metre high tower formed of stacked precast concrete modules, has completed as part of an OMA-designed housing development in Stockholm.
Recent (ABC) Projects

Innovation Tower completed in 2018
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Precast Concrete Case Studies
Case Study: Champagne - Quarry Calgary, Alberta

- Champagne - Quarry Park in Calgary is a recent example of what is happening in many parts of the country where former industrial lands along water-ways near city cores are being rejuvenated as self-contained communities.
- In this case, over 162 hectares [400 acres] of a former brownfield site in southeast Calgary near the Bow River, which once included a gravel extraction facility for Lafarge Canada, has been master planned as a mixed-use community with many amenities.
Case Study: Champagne - Quarry Calgary, Alberta

The project comprises five individual four- and five-storey buildings located on top of two levels of interconnected underground parking. The architecture is French provincial, which is supported with details such as natural stone and steep-pitched roof lines. It has balconies and large windows, and arched detailing over the top windows.

Colour palettes, construction materials and specifications differentiate this property from any other in Alberta. Precast was chosen for its resilience and inherent fire resistance - both being key requirements for this property. The interior uses long-span concrete hollowcore floor slabs supported by precast concrete shearwalls.
One Forty Nine is a seven-storey total precast apartment building consisting of (73) one & two bedroom units ranging from 530 to 800 square feet. The city of Hamilton required the building finishes to match the surrounding properties therefore a stone & brick formliner was proposed for the project. The end result is a modern building with a traditional historic look.
Total precast was an economical solution for this project due to the tight site restrictions and access. Furthermore, the erection timeline was far quicker than the traditional superstructure with a brick and stone veneer. One entire level (9,000 square feet of precast hollow core floors & 7,600 square feet of precast walls) was erected in just five working days.
FWBA Architects worked with precasrer to replace the traditional building method of this care facility with an innovative total precast concrete building solution. Since its inception, the project has been a rewarding journey of integrated design, collaboration, value engineering and cross-functional brainstorming meetings. The structure, supplied by Armtec, is comprised of architectural double wythe insulated wall panels, solid interior wall panels, precast columns, stair stringers, steel Deltabeams and hollowcore floor and roof slabs.
This building method facilitated a fabrication and installation schedule of mere months – starting with precast production in June, precast installation starting in August and completion by the end of November.

This aggressive schedule is very much in line with the province of Alberta’s commitment to building an inventory of 2,000 continuing care beds as soon as possible. Building these facilities with traditional construction materials would not be possible under these tight and accelerated schedules. Total precast construction provides a state-of-the-art solution for continuing care needs by delivering a safe, fast, sustainable and resilient building.
Case Study; St. Teresa Place Supportive Living Facility Calgary, Alberta
The Onyx at Barrel Yards, Waterloo
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The Onyx at Barrel Yards, Waterloo
The Onyx at Barrel Yards, Waterloo

In comparison to a similar nearby traditional project also under construction, the Barrel Yards Precast Concrete Project started six months later and finished four months earlier, which greatly reduced construction and financing costs.
# High Performance Attributes and Benefits of Precast

<table>
<thead>
<tr>
<th>VERSATILE</th>
<th>EFFICIENT</th>
<th>RESILIENT</th>
</tr>
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<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>
</tr>
</tbody>
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Additional Resources

Architectural Precast Concrete

New - Architectural Precast Concrete Walls: Best Practice Guide
New - Meeting and Exceeding Building Code Thermal Performance Requirements
CPCI Maintenance and Inspection Manual for Precast Concrete Building Enclosures
High Performing Precast Concrete Building Enclosures - Rain Control
Architectural Precast Concrete Repair Guide
Insulated Wall Panel Technical Guide
Architectural Precast Concrete Technical Guide
Colour and Texture Selection Guide
QUESTIONS

Precast Concrete Builds on ... Accelerated Building Construction (ABC)

For more information: www.cPCI.ca