The need for certainty in design is increasing in demand in the building industry. The ability to clearly see and understand all factors that influence a potential building is proving to be essential in efficiently creating high performance buildings, particularly with unique forms.

Computational design, a hybrid of computer programming and design, meets this need as a tool that can be used to accelerate the design process and optimize building performance and construction, all in a cost-effective way.

Perkins+Will, in partnership with RDH Building Science, was provided the opportunity to develop a unique building enclosure for two residential towers at Orchard Commons, the University of British Columbia’s (UBC) new academic and student housing facility. The University had two main goals for the enclosure, to create a compelling visual identity for the facility and to create a high performance envelope achieved through an efficient and affordable design and construction process.

Perkins+Will’s solution was to apply computational design to optimize the building envelope to achieve the University’s goals. The choice to use precast concrete sandwich panels

A combination of factors led the design team to arrive at a precast concrete sandwich panel and window wall enclosure system for the residential towers. The University had a positive experience with the precast concrete wall system on a previously built residential facility on campus and was interested in receiving the same energy performance and cost benefits.

As the University owns, operates and maintains their building stock, the expectation for durability is a driving consideration. Their approach to building requires good energy performance and other sustainability goals, with Orchard Commons targeting LEED Gold certification. The project’s demanding construction schedule and lean budget meant the speed of construction was also critical, favouring prefabricated cost-effective approaches to the enclosure.

These four considerations led the team to compose the towers of relatively small areas of triple-glazed curtain wall and thermally broken prefinished
metal, with the majority of the building being clad with a combination of window wall and precast concrete sandwich panels.

Realizing the design intent

The distinctive design for the residential tower façades was developed intuitively through iterative cycles of design, review and approval, until a concept was reached. To create an identity that was unique and distinct from other residences on campus, the design team was interested in expressing the plastic nature of concrete, and sought to challenge conventional orthogonal shapes.

As a result, the expression of the opaque wall is characterized by irregular shaped sides and a raised profile at the centre of the panels. Although fluid or natural forms are easily achieved with concrete, they have the general perception of increased complexity and therefore cost. Throughout the process of the architectural design, computational design (using an authoring tool called Grasshopper, an add-in for Rhino 3D) was used to distill design intent and explore geometric variations for the façades in pursuit of a geometry optimized for simplicity of construction and cost-effectiveness.

By using a computational model developed by Perkins+Will, parametric controls were applied to allow real-time modifications to the geometry with the ability to control exact targets of opaque wall to window. Using this tool, the team was able to consult with the University in real-time, modifying the amplitude of the curving forms, the extent of the cladding and the composition of the windows. To optimize cost and schedule further, the design team elected to complete the corners of the buildings using the window system, in part to eliminate the additional custom concrete pieces that would otherwise be required.

The panelization was optimized to require only 18 unique concrete forms in order to cast the outer wythes of the sandwich panels. In total, about 1,200 panels were prefabricated by APS Architectural Precast Structures and assembled on site with “just-in-time” delivery from the plant. At the same time, the process for generating documentation for the window types was developed, automating the workflow between the two systems that made up the enclosure. To have greater commonality among the window types, the width of the inner wythes of the sandwich panels were optimized to allow windows for three floor stacks to be identical.

The cumulative effect of applying computational methods to distill design intent and optimize the façade geometry using real-world construction constraints resulted in a value proposition and risk mitigation that was well received by the client, contractor and fabricator. This new process for working with bespoke modular building systems—distilling design intent first, optimizing second, and defining the modular blocks to build with third—has proven to change the dynamics within the design team, reducing uncertainty using this tool, the team was able to consult with the University in real-time, modifying the amplitude of the curving forms, the extent of the cladding and the composition of the windows.
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and allowing more time to refine the design to meet objectives.

Making it work
In parallel with the design of the precast concrete sandwich panels, the technical details were developed to ensure the design intent was able to be delivered in a practical way. With limited use in the Vancouver market, the approach to detailing began with first principles and led to a custom strategy that responded to the particular nature of the installation and the panel geometry.

The sandwich panels are composed of a 75 mm inner wythe of concrete, 75 mm of rigid insulation (extruded polystyrene), and a profiled outer concrete wythe with a minimum thickness of 75 mm and maximum of 125 mm. The inner and outer wythes are connected through the rigid insulation with fiberglass ties. Steel connection and hoisting elements were cast into the inner wythes of the panels. The combined effect is an effective R15, a continuously insulated cladding system. To achieve the bright white appearance of the panels, white aggregate, sand and cement were used, and great care was exercised to avoid staining during transport and erection. A transparent water repellent coating was applied after erection and cleaning.

It was important to resolve the installation details for the sandwich panels and window system together to achieve a reliable and durable building envelope and to optimize the construction process and simplify installation. Sandwich panels were installed using mobile and tower cranes, while windows were pre-loaded onto each floor and installed from the inside. To make the sequence simple and reliable, computation design was applied to simplify the locations of the connections to avoid conflict with the common continuous setting angle applied on top of the floor slabs. The inner wythe of the sandwich panel would bear on the floor slab, and the inside face of the panel would be installed against the setting angle with the window similarly set against the same angle.

Both the sandwich panel and the window bypass the slab edge to provide a tidy appearance and to offer thermal resistance. A continuous flashing detail at each floor level was coordinated to work across both the precast panels and windows to create a uniform through-wall condition. While the size of the panels was not a limitation, the team chose to limit panel height to match the floor-to-floor height and to optimize the detailing with adjacent windows. The irregular geometry of the exterior wythe of the precast sandwich panels extend in front of the orthogonal wall frames. Doing so allows the dynamic expression on the façade while retaining simple rectangular shapes for the windows and interior wythes—both of which are simple rectangles with a repetitive logic.

Achieving this configuration was enabled by the fact that the precast sandwich panels were installed first, with the windows installed second and from the interior of the building. Careful consideration for the arrangement of the slab bypass on the window frame was necessary to ensure the windows were able to be installed without clashing with the overlapping precast panels.

A winning combination
In a very real way, the application of a computational workflow enabled the design concept to be realized. A conventional workflow would not have provided the ability to control variables and gain the certainty required to optimize the design and detailing of the enclosure while meeting the schedule and cost goals.

The fluid organic forms of the façade have provided a recognizable identity for Orchard Commons and a defining characteristic of the residences. At the same time, the merits of the enclosure system fulfill the University’s requirements for durability, high-performance and value for the campus.

Derek Newby, Architect AIBC, MRAIC, CPHD, LEED® AP BD+C, is an architect and Senior Associate with Perkins+Will in Vancouver, British Columbia, with the distinct ability to deliver practical yet innovative and elegant design solutions, fostering a holistic approach to every project. He led the design of Orchard Commons on UBC’s Point Grey campus that innovatively used computational design to create its distinctive façade.

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