The ‚Flying' Stair at the University of British Columbia's Earth Sciences Building

Schwebende Treppen der Univerity of British Columbia

Les escaliers en suspension de l'université de British Columbia

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1. Introduction

UBC Earth Sciences Building, West Facade

The new 160,000 square foot, 5-storey Earth Sciences Building (ESB) at the University of British Columbia's (UBC) Point Grey Campus in Vancouver officially just opened this November. It houses the departments of earth and ocean sciences, statistics and mathematics and the dean of science. The ESB is a centre of discovery and learning that embodies the impressive academic and physical scope of the UBC campus.

It is an outstanding demonstration of leading edge fusion between international technologies and British Columbia design concepts. ESB also provides a snapshot at a pivotal time in the Canadian timber industry; it was designed just as solid wood construction was preparing to enter the local market – anticipated constraints on material availability informed a number of the innovative aspects of the structural system.

The north wing and atrium structure includes several state-of-the-art and innovative structural elements, including a wood-concrete composite floor system composed of 89mm LSL panels, elegant exposed heavy timber ductile braces for seismic resistance and full storey composite transfer trusses over the large ground floor lecture theatres. But it is by far the affectionately dubbed "flying staircase" in the entrance atrium that steals the show, as it soars five stories above the lobby in apparent defiance to gravity.

2. The 'Flying' Staircase

Located to the right of the impressive open concept atrium that links the academic and laboratory wing is a 5-storey free-floating cantilevered solid timber staircase.

Purposefully located away from the elevator cores, the architects hoped that the stair, which is oversized for this purpose, would become a meeting place and point of social interaction between faculty sharing the facility.

ESB Staircase architectural rendering

The original architectural concept for the stair is shown here to the right. You will note from the model that the stair begins with two intersecting stair runs at the bottom, both of which have an intermediate landing. We requested from the architect that the two intermediate landings be aligned with each other and the column between and beyond them. This allowed us to introduce a steel beam element which runs between the two columns in the background, and then cantilevering through the outer column into the atrium space to support both intermediate landings. This beam is left exposed from the underside in the interest of structural clarity.

The model also clearly indicates the architect's desire to have the three upper stair runs cantilever freely from the bridge floors with no other means of supports. Should we hang from the roof with discreet cable hangers or cantilever from the conveniently located column beyond? Initial concepts included various treacherous tricks designed to achieve the desired appearance without the obvious engineering complications. The need for structural honesty however eventually prevailed, and we found ourselves tackling the challenge of designing a rigid folded timber plate.

Cantilevered scissor stairs are both cantilevers and torsional elements, due to the pronounced offset between the opposing stair runs. High shears develop at the intersection of the two stair runs, which push against each other through the connection to the landing. More critically, a significant degree of stiffness is needed to meet the deflection and vibration criteria. This is relatively easy to achieve using welded structural steel or concrete which can be poured monolithically; somewhat more challenging in wood. The key is clearly in the strength but also the rigidity of the connections.

We first considered using cross laminated timber for the stair runs and landings due to the two way bending capability of the material. We however developed an alternate plan to resist the cross bending, torsional and high shear forces in the landing in a different manner, which allowed us to use glued edge laminated panels (glulam on the flat). We preferred this option because of the better finished appearance of glulam over CLT, but more importantly because of the greater strength and stiffness in the longitudinal axis of the stair runs, where we needed to achieve the most difficult connections.

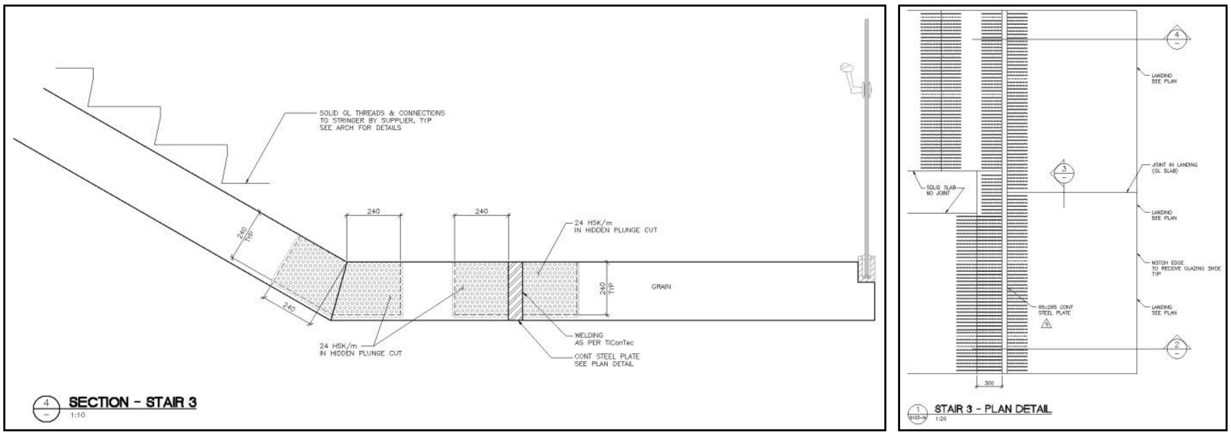
The solution was to introduce a steel element across the width of the landing plate. We first considered a circular pipe, then settled on a solid 62x254 mm steel bar, which remains visible from the underside, strengthens the landing plates across the grain and helps distribute local stresses at the intersection of the stair stringers where the high scissoring forces meet.

A cantilevered structural glass guardrail is attached to the stair structure through a steel shoe fastened into the glulam. The stair wearing surface is covered with a thin sheet of slip-resistant aluminum, which is recessed in shy of the edges, leaving a band of exposed timber to view along the perimetre. Sprinklers and lighting are also recessed into the underside of the structure.

3. The Connections

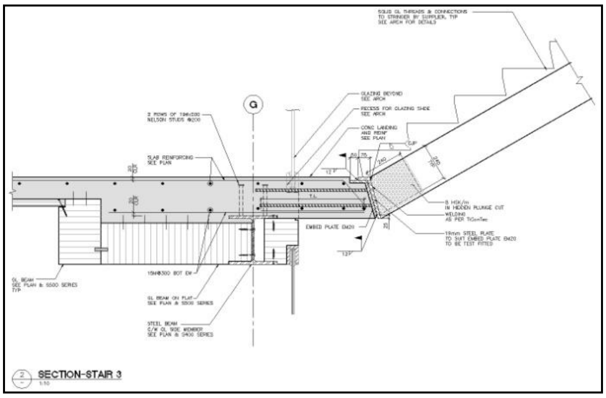
Having used the Holz-Beton-VerbundSystem (HBV-System)™ developed by professor Leander Bathon to achieve the wood-concrete composite connections in our floor structure for this project, we quickly thought of using the similar Holz-Stahl-Komposit-System (HSK-System)™, 'wood-steel composite' system to achieve the stair connections. Much like HBV, the HSK system consists of perforated steel plates which are epoxied into the timber elements with a proprietary adhesive. The system has the required strength and stiffness, and is particularly well suited to the connection of folded plate elements.

We worked closely with Dr Bathon to develop concealed connections between the runs and landings. Referring to the typical stair section and landing plan below, both wood to wood and wood to steel connections were required due to the asymmetry in the plan of the landing.



Typical stair section and plan detail at landings

In the wood to wood case, a series of tightly spaced HSK plates are slotted into the timber across the joint and secured with the proprietary adhesive. In the steel to wood portion of the connection, the proprietary HSK plates are welded to the steel cross bar on either side and then again epoxied into place, connecting the two timber elements on either side together while incorporating the steel bar into the landing structure.



Typical stair section detail at floors

The connection of the stair runs to the wood-concrete floors, which carry significant shear and axial loads, were to be achieved with the field welding of a steel plate attached to the stair run in the shop with HSK plates, and an embed cast into the floor topping as shown in the sectional detail to the right. The contractor ultimately chose to delay the casting of the floor until the stair was erected with the full connection in place, to ensure better accuracy and the need for field welding in proximity to the wood elements.

The stair risers were installed after the stair plates were in place, with the use of numerous pre-drilled self-tapping screws. The glass guardrail steel shoe was also secured to the stair plates with self-tapping screws.

4. The Installation

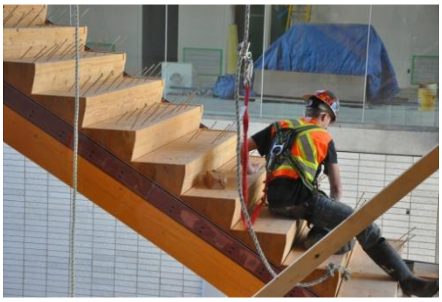
The geometric complexity, high expectations in finish quality and the intricacy and uniqueness of the connections required a high degree of skill from both the fabricator, Structurlam Products and the erector, John Boys of Nicola Logwork, both from the interior of British Columbia.

The stair structure was scaffolded and erected from the floor up, with intersecting stair runs secured first, and the connecting landing being dropped in afterwards and glued into place. All elements were craned in from the roof, which had been left open for the installation.

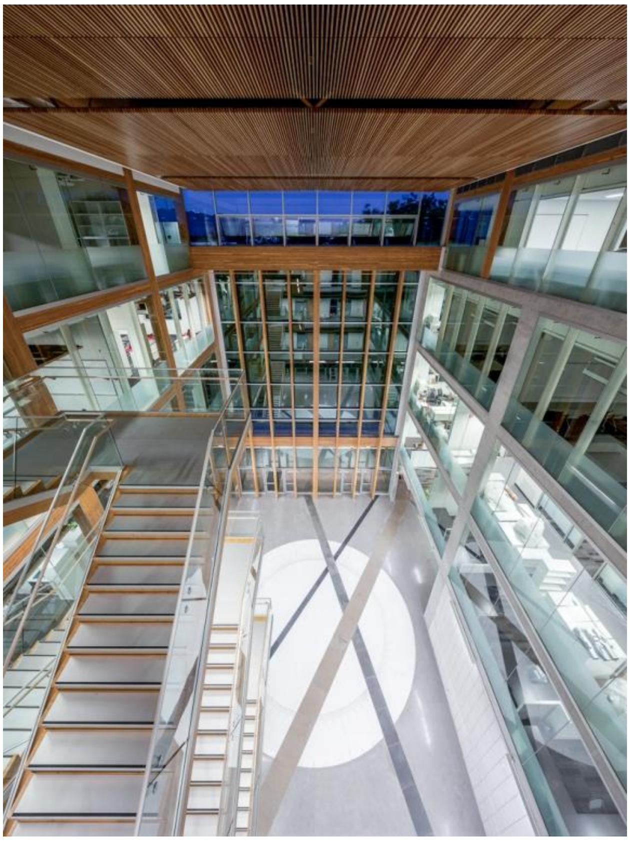
Quality control for the installation of the epoxy is achieved in part by injecting the adhesive from the bottom up wherever possible, allowing for the air to escape through vent holes, and by checking volumes of glue used against theoretical values at each critical stages of the installation.

Standing on the fifth floor bridge during construction, we looked down at the nearly completed stair and lofty atrium surrounding it, wondering whether the building users would be scared of stepping onto the daring structure. It appears that ignorance is bliss, as no one seemed to question the integrity of the beast and now use the ladder as they would any other.

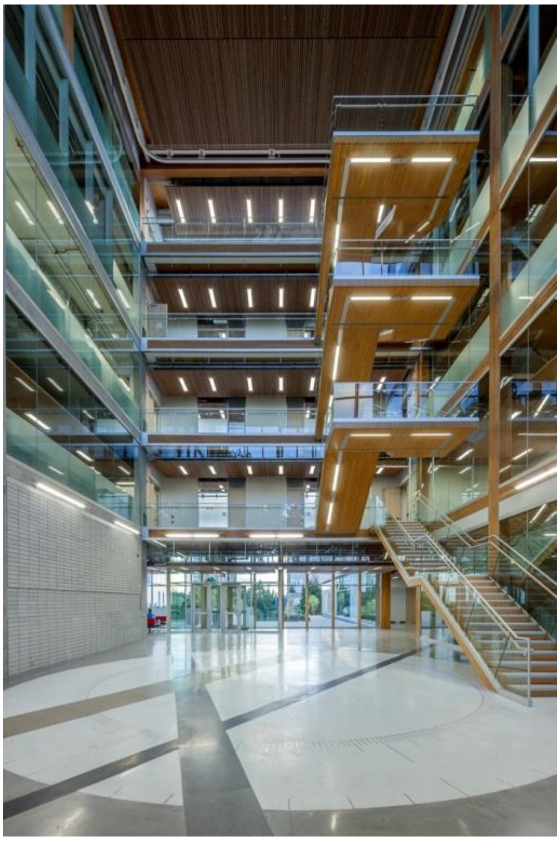
The apparently seamless folding "ribbon" hangs high as a testament to the beauty of wood, and the technology that makes its use almost limitless.



Stair case erection process



ESB Staircase; view from the fifth floor



ESB Staircase; view from the entrance atrium