BC HYDRO HQ: DESIGN AND CONSTRUCTION CHALLENGES ON A BARREL ARCH CANOPY REPLACEMENT PROJECT

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BACKGROUND

The main headquarters building for BC Hydro (BCH) is a landmark building constructed circa 1992 in the commercial downtown area of Vancouver British Columbia. 19 Stories tall, it features granite (and concrete) cladding as well as coloured glass skylights and canopies at the top and bottom – intended to mimic or invoke the mountains of British Columbia, and to suggest a tall waterfall descending each face of the building and cascading into arched canopies at each entrance. In 2013, our firm was retained to conduct a condition review of the entire building envelope.

Figure 1: Main Entrance and Side Canopy

Among the concerns noted in that review, was on-going leakage at the lower-level glass skylights and canopies, in spite of regular repair programs. Subsequent detailed evaluations identified the existing conditions, causes of leakage and other concerns, and presented several options for repair. This paper presents the decision process in determining a repair process, and the many changes necessitated or experienced during the repair program.

The building has three grade-level semi-barrel arch canopies over side entrances on the north and south elevations. The main façade entrance (facing west) is a series of three levels / floors of semi-barrel arch cascading glass canopies that widen out at each subsequent lower level. Again, intended to invoke the appearance of a waterfall – reflective of the Brutish Columbia landscape and the major source of electrical power in the province – hydroelectric generation.

The side entrance canopies, and the lowest level of the main entrance at-grade are exterior space canopies. However the main entrance continues up two more levels to enclose a three-storey atrium, which is conditioned (heated and cooled) interior space. All of the original construction was single-glazed, with a specially selected blue tint and the outer pane laminated. The glass was supported on "vertical" (i.e. perpendicular to the horizon) aluminum rafters with pressure plates and prefinished cover caps, installed in sections to allow for the semi-circular shape. Horizontal joints were structurally sealed. Rafter sections were themselves supported on hollow-steel structural frames which are tied back to the (primarily) concrete building structure. There is one added geometric complication, in that a small full barrel-arch section intercepts and projects out from the lower center over the main doors and supporting building signage.

EVALUATION

It was determined that many of the past leak repair attempts had consisted of filling the rafters (above and below the pressure plates) with sealant, and with sealing the cover caps. Absent any other considerations, the most cost effective repair option was to rehabilitate the existing frames: to remove all of the excess sealant, reconfigure the existing rafters to improve water-shedding at the exterior face and improve drainage on the interior, and to replace all of the glass with new single-glazed lites to match the original but present a consistent appearance. As well, there would be modifications to correct or improve limitations of the existing system, for example: introduce as much slope as practicable on each of the top rows of glass – which were essentially flat and unable to drain surface water; improve the drainage within the rafters and condensation handling, etc.

Repair of the existing system was the preferred and expected approach, except that we had concerns about the performance of the system during a seismic event, and recommended a more detailed structural review. Our initial concerns were related to attachment of the rafters to the structural frame, and the performance of the supporting structural frame.

The aluminum rafters themselves we attached to the structural frames with "U"-shaped clips installed at regular intervals - the bottom of the U bolted to the frames, the upper legs to either side of the rafter above. There was a large variation in the installation condition of these clips, many were not attached sufficiently to one or the other element (frame or rafter). Another concern was that, because the structural frames and the rafters did not follow the exact same arc (the glass being more segmented than the frames, etc.) spacers were used under the clips and many of these were also not sufficiently attached. Any rehabilitation program for the rafters would also have to address these many deficient attachment concerns of the rafters to the structural

frames.

Finally, a dedicated structural review of the seismic performance of the structural frame indicated weaknesses in the performance of the main entrance. Modelling indicated there would be significant damage and loss of structure in the case of an anticipated design seismic event. Whereas the grade-level canopies are attached on the outside of the building façade, they would likely move with the façade during anticipated seismic movements (assuming adequate securement to the building structure, which appeared to be the case), the main entrance is actually a weaker space or "void" between two building extensions. The two arms of the building could move at different frequencies and directions during an event, and the glass area (being weaker) would experience considerable damage. The Province of British Columbia was about to adopt a revised standard for seismic design, and being a prudent Owner BC Hydro felt seismic performance should be a significant factor when considering repair approaches.

DESIGN AND CONSTRUCTION

The selected repair program was augmentation of the existing structural frame and attachments to the building, and complete replacement of all of the glazing including rafters and attachment clips with a new glazing system.

The option to install sealed insulating glass lite over the conditioned space was considered as an alternative, but not expected to be part of the final solution. BC Hydro retained PCL as the General Contractor, who retained all the subcontractors and oversaw construction.

For many reasons, including the extremely active, public and prominent nature of the building and its entrance, the extent of scaffolding, hoarding and other site protection put in place by PCL for construction was significant, and a large part of the restoration consideration and cost. This approach also yielded benefits in site access and safety – almost all levels were readily available and protected for all trades throughout. Especially so since just after erection the front of the hoarding became a sit-in protest camp site. Other important considerations included the most appropriate and best way to protect the large and significant totems in the atria. Consultation with First Nation Elders determined that they could remain in place and put to sleep for the duration of the project.

The seismic modifications to the structural frame were designed, and included the introduction of new Hollow Steel Section (HSS) members to be welded in place – primarily diagonals in the outside bays but with one additional horizontal member across the entire width of the glazed area. Some minor revisions were designed for the attachment conditions as they were shown on the original drawings. This aspect of construction proceeded essentially as designed, with a few minor considerations: attachment points were modified to allow for easier construction, partly to reduce the amount of opening into the existing cladding to get access for the attachment reinforcement works. A revision to the geometry of the new members was considered, with a view to best line up with the new horizontal structural seal butt joint line of the glass panels. This alignment issue was also a concern with the vertical joints as well.

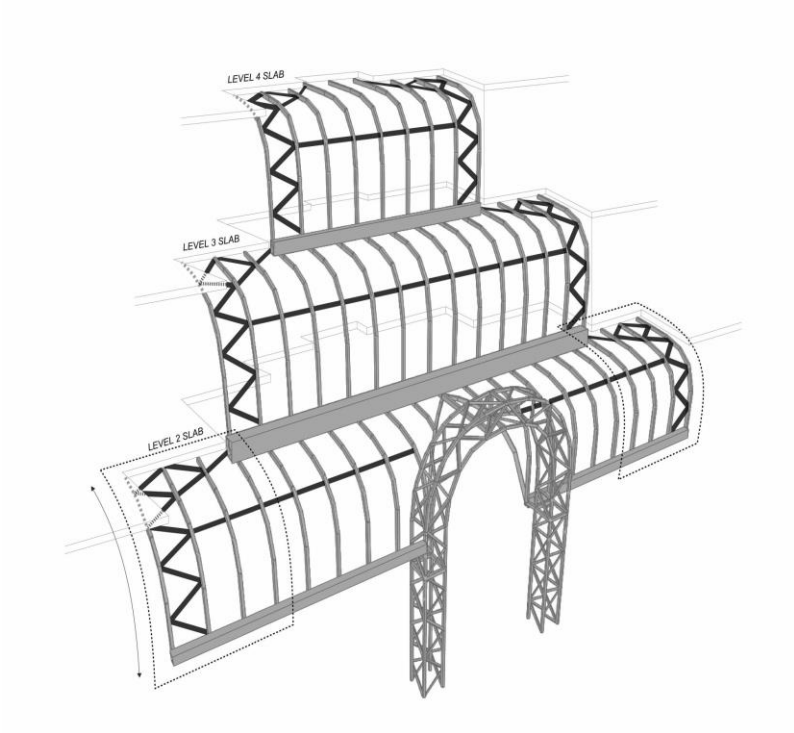

Figure 2: New Structural Members Main Canopy

The original design allowed for proprietary glazing systems, with some guidance for improvements. For example the top row of glass lites: a) had minimal counter flashing protection at the susceptible intersection with the walls, and b) were essential flat, with no slopes to drain away from the wall. The design called for positive slope to drain of each upper row, more extensive protection at the connection to the vertical walls. Improvements and replacements to the lighting contained within the main canopy were also incorporated into the design. During the extended project planning and funding allocation phase among the significant changes was: the upper 2 levels of the main skylight were replaced with a new proprietary system - but with sealed insulating glass lites on new rafters. The outer lites were tinted and laminated, the inner lites tempered. On all of the lower, grade-level canopy sections the original rafters were cleaned and attached to the structural frame with new clips, and new single-glazed lites installed. The upper row of (horizontal) glazing was sloped as much as possible within the limitations of the existing frame and wall connections.

The net result matches the original well, with an almost identical tint, a fresher appearance with new paint finishes, matching glass lites, and improvements to the water shedding. From the interior, the additional structural members have some to appear as if they have always been there.

Though not part of our scope, and not required for justification of installing the insulating glass, we were curious about the net impact the use of insulating glass over the conditioned space of the atrium would have on the heating and cooling costs, and did some rough calculations. The net reduction in heating load provided by the new skylight system was estimated using a Heating Degree Day (HDD) calculation. Assuming a heating cost of $16/GJ, the savings in heating cost were calculated to be $1535.33 per year, in 2016 $CDN.