Canada’s Kicking Horse Pass extends 80km through the Rocky Mountains between the towns of Golden, British Columbia and Lake Louise, Alberta. The pass was first explored in 1858 by an expedition led by Captain John Palliser. The pass and the adjacent Kicking Horse River were given their names after James Hector, a naturalist, geologist, and surgeon who was a member of the expedition was kicked in the chest by his horse at this spot.

The pass is of historical significance to the region because the main line of the Canadian Pacific Railway was built through this route in the 1880s and when the Trans-Canada Highway was built in the 1960s it followed more or less the same alignment.

The highest elevation of the entire Trans-Canada Highway is on the Kicking Horse Pass, where it reaches 1,643m. Roger’s Pass, which is 100km west of Golden, is better known but about 300m lower. The Kicking Horse Canyon is the most westerly section of the pass and extends east from Golden to the edge of Yoho Provincial Park.

The current project involves upgrading the winding, narrow road that was constructed in the mid-1960s to a modern four-lane standard to improve safety and capacity. The corridor includes two existing bridges, the Yoho Bridge and the Park Bridge. The first phase was replacement and widening of the Yoho Bridge, which was completed in 2006, while the second phase is the Park Bridge replacement, due for completion early next year. A third and final phase linking Golden to the Yoho Bridge is currently in the planning stage.

These projects were deemed necessary due to the treacherous driving conditions of the region. The number of vehicle accidents in Kicking Horse Canyon has more than doubled the provincial average, with avalanches, rock slides, and mudslides a constant hazard to motorists. The Highway can be closed for hours, sometimes days, while heavy equipment struggles to reach the blockage and clear the road.

Phase two involves the replacement of the existing Park Bridge, construction of new retaining structures, upgrading of the approach curves and the construction of over 3km of new highway.

The Trans-Park Highway Group consisting of Billinger Berger, Flatiron Constructors Canada, Parsons Overseas Company of Canada, and HMC Services was selected in a competitive process for a public-private partnership to design, build, finance, operate the entire 25km canyon section between Yoho Bridge and the start of Yoho National Park.

The existing highway has only one lane in each direction and winds through extremely rough and steep mountain terrain. The scenery is beautiful, but the road is very narrow and unforgiving, and drivers must concentrate on the route ahead. At the bottom of the steep canyon walls, the highway crosses Kicking Horse River and the Canadian Pacific Railroad. In order to improve the existing alignment, the new bridge is being built high above the river to connect into new sections of highway on both sides of the canyon.

Because of the elevation of the bridge above the canyon and limited access to the site, the team chose to build a curved steel plate girder bridge by incremental launching from the west side to the east side of the canyon. TPHC retained KWH Constructors Corporation to work with structural engineer Parsons on design considerations to accommodate the temporary launching stresses, devise the launching scheme, design and build proprietary equipment for launching the steel superstructure, and carry out the work.

The new bridge is just over 400cm long and at its highest point is about 90cm above the canyon floor. It has six spans ranging from 50cm to 80cm and the roadway alignment is on 6% longitudinal grade and is horizontally curved with a constant radius of 500m. The bridge deck is just over 23m wide and it is designed to accommodate two lanes of traffic in each direction. The superstructure consists of four main steel girders and three substructures that are supported on intermediate cross-frames. The main girders are 3m deep and they are spaced 7m apart. Five concrete piers support the bridge, ranging in height from 40m to 90m, and were built using the cast-in-place jump form system.

One of the most unusual features of this bridge is that it is a horizontally-curved steel plate girder superstructure that has been erected by incremental launching and is believed to be the largest of its type in North America built using this method. The bridge was launched in two phases from an assembly area at the west abutment; each phase consisted of a fully assembled pair of girders complete with cross-frames, plan bracing and substructures. After completing the second launching phase, middle bay cross frames and substructures were installed between the girder-pairs.

KWH Constructors’ full scope at the site was to assemble the girder-pairs, launch the girder-pairs into position, jack down the girder-pairs onto the permanent bearings, and...
install the middle bay cross-frames and stringers between the girder-pairs. Construction engineers from Somerset Engineering were also involved.

The bridge was launched as two separate parallel girder-pair units, the weight of each being about 1,300t. When assembled, the cross-sectional envelope of a girder-pair was more than 3m tall and almost 8m wide.

The overall scheme used to erect the bridge can be divided into four separate elements: assembly bed, nose girders, pier equipment, and launch system. The assembly bed was a 125m-long area to the west of the west abutment, which was sloped to the same 6% grade as the bridge end and was used to assemble girder-pairs. Individual girders were brought to site on trucks and were then raised and placed into position in the assembly bed using a 200t crane. The longest of these girders was 36m and the heaviest was 55t.

The launching nose was formed of a pair of temporary girders, approximately 25m long and weighing nearly 30t, bolted onto the leading end of the girder-pair. It was designed to accommodate predicted deflections of up to 1.8m of the leading edge of the girders when landing at the pier ahead. It also helps guide the girder-pair into correct transverse alignment.

On top of every pier and on both girder lines was a set of guide brackets and roller brackets. The latter consisted of equalizer beams supporting two Hilman rollers that were temporarily welded on top of the permanent bearing plates. The guide brackets were attached to the pier top via the permanent anchor bolts and were adjustable transversely in order to help maintain proper girder-pair alignment.

The launch system itself had four major components: flange clamps, launch cylinders, wedge brakes, and return carriage. The flange clamps used specially-designed 250t rails set into heavy reinforced beams, providing more than 40MPa of pressure to hardened jaws that were clamped against the edges of the girder-pair bottom flange. This provided sufficient friction capacity to grip to the girder-pair as it was pushed uphill. There was a total of four launch cylinders, two per girder, each with a capacity of 80t and these were each pinned at one end to the flange clamp and the other end to a frame anchored to the west abutment.

After clamping against the bottom flange, the launch cylinder rams would extend by 1.5m, taking the flange clamps and girder-pair with them. The wedge brakes restrained the girder-pair from rolling back, using thick wedge plates set against each girder flange edge. As the girder-pair attempted to roll down the slope, the flange flanges were gripped by the wedge plates and both were tightened into specially-designed hydraulically-actuated beams. As the bridge was being pushed eastwards, hydraulic cylinders retracted and disengaged the wedge brakes.

The function of the carriages was to return the flange clamps and launch cylinder rams to the retracted position after each push, and they consisted of two vertical hydraulic cylinders riding on guided wheels. The carriage also kept the flange clamp in the correct alignment with the bottom flanges of the girder-pair.

The cycle of the launch system was clamp, release wedge brakes, extend launch cylinders, apply wedge brakes, unclamp, retract launch cylinders. One cycle normally took about five minutes; it took about 50 cycles of the launch system to complete an 80m launch and more than 250 cycles were used to fully-launch one girder-pair. The sequence for the scheme was to assemble sufficient length of a girder-pair in the assembly bed and then launch to the pier ahead. This sequence was completed six times for each girder-pair.

Computer models of the superstructure were used to determine the deflection of the nose tip for the maximum cantilever. In order to limit the girder-pair stresses in the 80m-long cantilevers, these deflections and the launching nose design were coordinated to ensure that the tip of the nose would land directly on the roller assemblies at the centre of the pier ahead. For the shorter spans of 50m to 70m, which were less critical, the launching nose landed on the roller assemblies further along its length.

After a girder-pair was launched six times, crossing the entire 400m from west abutment to east, the girder-pair at each pier was jacked down onto the permanent bearings. After both girder-pairs were launched to their final position, the last step was to join together the girder-pairs with middle bay cross-frames and install the middle bay stringers. KWH started assembling the launch equipment and girder-pairs at the west abutment in early December 2006, launched the first span of the first girder-pair in middle of January this year, and the last span of the second girder-pair in the middle of May. Launching was substantially complete when B&SE went to press, at which time the general contractor installed precast deck panels and the cast in situ concrete deck.

In order for the launch process to work, several modifications to the typical superstructure design and detail were required. The bottom flanges of the girders were a constant width for the entire length of the bridge to allow both the flange clamps and the wedge brakes to function. Girder splices were designed with a gap directly under the web to allow the splices to clear the roller assemblies.

Because the girder-pair was intended to roll over the top of the launch system, it was necessary to ensure that there would be no interference between the bridge and the launch system, and some of the pier brace members at the bottom flange required shop-fabricated notches to allow for adequate clearance. The bridge engineer designed the leading two spans of the superstructure with top and bottom plate bracing to accommodate the eccentricity and resulting torsional forces during the curved launch.

The launch system was fabricated, assembled and tested at the KWH yard in Vancouver, confirming that the wedge brakes and flange clamps had at least 110% capacity for the launch design loads.

The final commissioning took place during the first launch and initially, due to challenges with the hydraulic systems and the tolerance requirements of the launch system, it took nearly three successive ten hour shifts to launch the first 50m span. By the fourth launch, the 80m span required about eight hours to complete, while the eleventh launch of 80m span was completed in about four and a half hours.

The hydraulic rams and cylinders of the launch system were operated from a self-contained unit and all equipment was operated by a PLC system supplied by Conformed Automation Systems. It also monitored the system during the launch and automatically performed some of the steps in the launch cycle. The control system was designed to run an entire launch cycle independently and the programming could and was modified during the project to add safety features and streamline the launching cycle.

One important aspect of the superstructure launch was that officials from TPHG, the Ministry of Transportation, and the Canadian Pacific Railway, convinced of the safety of the launch system, allowed the launches to proceed with ongoing vehicle and train traffic below - without any delay or disturbance to either.

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