INDUSTRY REPORT Civil Engineering: Quiet Giant in Alberta's Industries

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Engineered to the Extreme

Volcanoes. Frigid temperatures. Hurricane-force winds. You name it. Alberta's civil engineers are ready to conquer it

By Connie Bryson

With more than 30 years experience working on pipelines in extreme environments from Alaska to Argentina, Calgary-based civil engineer Wim Veldman figured he'd seen it all. Still, he wasn't prepared for what he encountered upon finalizing the design of a pipeline under construction in Ecuador – two weeks after a volcanic eruption in the area. "The debris flows had caused utter chaos," recalls Veldman. "The rivers were still smoking and steaming, the smell was almost enough to knock you out and you could barely see a thing. I was thrilled. I turned to the local engineer and said 'This is great. We are actually seeing what nature is doing.'

"Just then, we heard something coming down the mountain. It was another flow! We thought we would lose the main highway bridge. We thought we were trapped."

Fortunately, it turned out to be a minor debris flow; Veldman and his colleague made it out safely. But the story underscores a point about extreme engineering. If you don't get excited by the challenges presented by extreme work – whether they be debris flows in South America, blizzards in northern Canada or hurricane-force winds in Russia – you should not be in this line of work.

Many Alberta civil engineers *do* get excited by these challenges and have carved out a specialty for themselves in extreme engineering. They are building mines, pipelines, bridges, community facilities and homes in remote locations, harsh climates and dangerous situations. And they love it. ▶

Wim Veldman is one of them. His Calgary-based company, Hydroconsult EN3 Services Ltd., specializes in river engineering for pipelines; coal and gravel mines; bridges; water intakes and floodplain development.

The success of this eight-person company is due to Veldman's expertise, especially in pipeline projects. His introduction to the field came in 1973 when he worked on the Trans Alaska Pipeline, connecting the Prudhoe Bay oilfields to southern markets (Trans Alaska Pipeline remains a Hydroconsult client). This work led to Hydroconsult's involvement in the five most recent major pipeline projects in South America. "The Andes are extremely difficult terrain," Veldman explains. "Because the slopes are so steep, the rivers are usually the only place to put a pipeline. This means not only multiple river crossings but often the pipeline must run right down the middle of a river for many kilometres."

One of Hydroconsult's South American projects was the Oleoducto de Crudos Pesados (OCP) crude oil pipeline. Completed in 2003, it transports up to 450,000 barrels per day from the jungles of the Amazon River basin across the 4,000-metre-high Andes to an export terminal on the Pacific Ocean. The $1.1-billion US pipeline runs mostly underground, with the exception of a handful of above-ground bridge crossings.

The OCP crosses more than 160 rivers – ranging from several metres wide to more than 400 metres in width. Hydroconsult was hired to scope out and design the river crossing and in-stream sections, review the construction of these sections and prepare a monitoring manual. The successful project won Hydroconsult two 2004 Awards of Excellence from the Consulting Engineers of Alberta.

There are all sorts of reasons to call the OCP project extreme: the dangers that come from burying a new pipeline in close proximity to an existing above-ground oil pipeline, a history of deadly landslides, the remoteness of the location and the very real threat of terrorism (kidnappings of foreign workers occur on a regular basis in eastern Ecuador).

But what makes the OCP project really stand out is the volcano. On Nov. 3, 2002, the Reventador volcano erupted, resulting in massive lahar flows – a deadly mixture of ash, lava, rock and water. Lahars raged through the river valleys in two main watersheds.

Local Extremities

Challenging projects closer to home include the Edmonton South LRT expansion and an underground transmission line near Banff National Park

While distant countries like Ecuador and northern Russia make for interesting project locales, you don't have to leave Alberta to find extreme engineering projects. In Edmonton, there's one right underfoot.

It's the $100-million South LRT (SLRT) expansion project – taking the LRT from the existing underground station at the University of Alberta to an above-ground station near the University of Alberta Hospital. Although it represents just 640 metres of track, the project is a tremendous engineering challenge. The issues? Geology and geometry, explains Bart Becker, SLRT project manager for Stantec Consulting Ltd., the managing consultant for the project. The geology is challenging because of large pockets of very fine sand in the area. "Tunnelling through soft ground like this is very tricky because of the potential for severe ground settlement," notes Becker. "Obviously, with all the buildings on campus, this was something we had to avoid." Some sections were pre-treated to solidify the sand prior to tunnelling. A 600-ton tunnel boring machine, specially designed for soft-ground tunnelling, was brought in from Singapore.

The other challenge was designing the route to avoid tight turns, which the tunnel boring machine cannot negotiate, and large underground utility corridors. Rather than relocating the utility corridors, which would have cost about $15 million, engineers opted to design the track with a relatively steep 6% slope. This required retrofitting each LRT car with an extra set of brakes (at a cost of about $7 million) to handle the slope safely.

The complex underground situation meant that project engineering took 18 months to complete. In contrast, each tunnel (there are two) took three months to excavate. The up-front care and attention paid off. There were no claims or change orders as a result of changed ground conditions – an almost unheard-of accomplishment in soft-ground tunnelling. The new section of the LRT is expected to open in December 2005.

Farther south, another challenging underground project is just beginning. Calgary-based SNC-Lavalin ATP Inc., a subsidiary of SNC-Lavalin Group Inc., is working on a $14-million contract to design and build two underground electrical transmission lines in the Rockies. The 4.2-kilometre, 138-kilovolt lines will replace two overhead lines that are part of the grid that supplies power to the Three Sisters Mountain Village Resort between Banff and Kananaskis. Three Sisters wants the lines buried for aesthetic reasons.

It's challenging work because the route runs through steep, mountainous terrain with a number of abandoned shallow mine shafts and sinkholes. For portions of the route, equipment access roads must be constructed on steep slopes and inclines. As well, construction will take place in close proximity to live overhead power lines.

Work began in April 2004 and is targeted for completion by October 2005. Over 100 people will be involved in the project. The job requires the installation of five concrete vaults and 4.2 kilometres of duct bank (PVC tubes encased in concrete) to house the power cables. Some of the duct bank will be placed under streams and standing water while other sections will be self-supporting and span the sinkholes and mine shafts.

The expertise required for this project – indeed all electrical transmission work – involves both civil and electrical engineering. SNC-Lavalin ATP has both disciplines in-house. The company formed in 2002 when SNC-Lavalin acquired the employees from TransAlta's electrical transmission business. "After two decades of very low investment in the transmission system, electrical transmission is in a significant growth mode in North America," says Cindy Andrew of SNC-Lavalin ATP. "Consequently our business is expanding rapidly with a number of contracts outside Alberta and opportunities in the U.S."

Sections of the Rio Montana and Rio Marker were covered with metres of deposited material and transformed into virtual moonscapes. The OCP pipeline, which had been welded in preparation for burial, was damaged. Veldman had to reassess the pipeline alignment and establish new burial depth criteria – a minimum of three metres into pre-eruption ground elevation. As a result, excavation depths in some areas reached 10 metres. Even large excavation equipment had to make multiple passes to dig that deep.

But that wasn't all. A huge rainfall in May 2003 mobilized even more volcanic material, this time on the Rio Reventador. The debris flows were 14 times the magnitude of a typical design flow. A highway bridge completely disappeared, a 30-metre-deep canyon was eroded into the highway and the existing elevated pipeline was severed. Even the just-completed OCP line was damaged, forcing a redesign, realignment and reconstruction. The redesign was done concurrent with construction so that the project could finish on schedule.

"This is why I love river engineering – I love the challenges," says Veldman. "Pipeline river crossings in the Andes are not things you can pick up a code book and design. You have to see the situation in the field. You have to talk to the local experts and local residents. You have to use the knowledge you've gained from previous projects. You have to pull this together and come up with innovative river designs that are practical solutions for these remote locations. Solving problems is what it's all about."

Although all of Alberta's extreme engineers are problem solvers, most of them find their work taking them north rather than south. "Alberta is one of the centres of expertise for cold regions engineering," says Daniel Smith, professor of civil and environmental engineering at the University of Alberta and one of the organizers of the Cold Regions Engineering and Construction Conference that took place in Edmonton in May. Smith notes that the main catalyst for cold regions engineering research has been major projects such as the Alaska Highway, the Trans Alaska and Norman Wells pipelines and oilsands developments. "Their needs have driven research and led to technological innovation. Now, much of this know-how has been transferred to engineering firms – many of them in Alberta." ▶