

Across the ice

Kristina Jarvis and Sam Proskin from Canadian engineering firm EBA, a Tetra Tech company, spoke to *Mining Magazine* about designing and operating ice roads

Every single time he stands on the Tibbitt-to-Contwoyto Winter Road (TCWR), a 405km-long stretch made of snow and ice in Canada's Northwest Territories, Don Hayley, an ice engineer with engineering firm EBA, always listens and watches for something very specific.

Having been part of the ice-road business since the late 1970s, Mr Hayley explains: "If you stand on the ice as a truck goes by, it sounds like your kid just poured milk on their Rice Krispies – snap, crackle, pop – you would think that's very scary.

"What you're hearing is the load being distributed through the ice. You have to be able to read the ice and listen to what it's telling you. If that crack goes all the way through and water comes up, then you have problems."

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Winter road changes

One of the very first recorded winter roads in North America was created by John Denison, a former RCMP officer in Yellowknife, Northwest Territories. He left the law-enforcement business in 1947, to start moving supplies across the north.

His operations and experiments with winter roads were documented in the book "Denison's Ice Road" by Edith Iglauer, a journalist from New York.

During the 1950s and early 60s, Mr Denison would use Caterpillar trucks, and knowledge gleaned by himself and from others about the north to build ice roads. These opened the door to a newer, and cheaper means of carrying supplies to all of the mines and camps along the routes that he created.

Dr Lorne Gold, an ice expert at the National Research Council of Canada in Ottawa, came up with the Gold's Equation as a way to calculate the amount of ice required to safely hold trucks and trailers hauling loads across the ice, and improve on Mr Denison's work.

At the time, the equation was adequate to predict the ice thicknesses needed for single-trailer transport trucks running to and from the mines.

Mr Hayley began working in ice engineering in the late 1970s. He says the reality of today's winter roads is that they are a lot bigger, heavier and more advanced, making Gold's Equation somewhat outdated.



At the time when Mr Hayley began working on winter roads, he thought that the idea of changing Gold's Equation and coming up with new methods for designing thicker, safer roads was radical, even though it was a necessity in the development of the winter road.

"Technologically, we have gone beyond that now and we use more refined techniques to define ice capacity," he says. "But we always come back to Gold's Equation and calibrate with that. We can't ignore all of that history."

Nowadays, Mr Hayley points out that drivers regularly use double-load trailers and flat-bed trucks to haul buildings, capital equipment and other large loads across the ice to the remote mines dotted along the TCWR.

Long time running

The TCWR is one of the world's longest winter roads, stretching northeast from Yellowknife and across the Northwest Territories-Nunavut border to three diamond-mining operations in Northern Canada's – Rio Tinto's Diavik, BHP Billiton's Ekati and De Beers' Snap Lake.

The TCWR has been in operation for about 30 years now. Mr Hayley says it is often designed using the heaviest load weight anticipated for the ice each season, with the help of the TCWR joint venture and the road's construction company.

Alan Fitzgerald is the current project manager for the TCWR at Nuna Logistics, the company charged with building the overland/over-ice road every year. ▶

A truck travels along the TCWR ice road with a haul truck body
Photo courtesy of Nuna Logistics



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Drilling in Siberia

In northeast Russia lies Lake El’gygytgyn, a crater lake that has sat frozen for 3.6 million years. It was the focus of an international consortium of scientists who were interested in what lies below the frozen lake, and what this could mean for climate change research.

In 2009, the group headed to Siberia to drill down to the bottom of the lake and take core samples to identify how climate change has affected the Earth.

Volker Neth, a German ice engineer who practices with EBA, designed the ice road and an ice pad for the drill to sit on.

Unlike ice roads, says Mr Neth, ice pads are designed to hold a stationary load and thus require a different approach to planning.

“The ice undergoes deformation, called creep. It deflects downward,” explains Mr Neth, adding that this deformation

really becomes an issue when it gets closer to the top of the water.

The space between the top of the ice and the top of the water is called the freeboard. “When I have a stationary platform with a stationary load, it’s this freeboard I watch for,” he points out.

Mr Neth has designed ice drill pads, ice bridges and ice roads across Canada’s north.

He says that challenges at the Siberian crater lake included working in a remote location with very limited resources and equipment.

However, he adds that the project was a unique one in his 30-year career.

“The scientists can figure out from the cores that were taken, what the Earth’s temperature was 10,000 years ago. It’s like an archive down there,” he adds.

“The road’s design is a process that requires a long lead time”

► About to undergo his fifth season on the road, Mr Fitzgerald says the planning process begins just after the last road melts away in the spring, allowing the mining companies to start projecting their supply needs and schedules for the following year.

Based on these requirements, along with terrain, safety, and environmental concerns, the design for the TCWR is shaped.

Mr Fitzgerald says the road’s design is a process that requires a long lead time. “The challenge that anyone has

up here in the north is the lack of infrastructure, whether it be by land, air or by sea. Working in a remote and isolated environment dictates a long planning and lead time. It’s an advantage and a problem all at the same time.”

Once the ice portions of the winter road have been built, frequent monitoring and safety checks become a regular part of ice-road life.

Signs dictating speed limits of 15km/h, 25km/h and 35km/h (9mph, 15mph and 22mph respectively) are



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placed along the road, and they are strictly enforced. Drivers and workers operating on the route must take a safety course before they are allowed on the ice highway.

Mr Fitzgerald explains that it is all in the name of safety – the slow speeds help to prevent blowouts from pressure waves under the ice, and the courses help to keep the workers and drivers safe during the season.

Sam Proskin, the current engineer of record for the TCWR, began working on the road with Mr Hayley about ten years ago, through their mutual work at EBA.

Mr Proskin, who is based in Edmonton, Alberta, says a major part of operations in more recent years have included working on risk management regarding the thickness of the road and what can be tolerated on the ice.



Cranes lower pipes into a trench between two ice platforms on the Caspian Sea Photo courtesy of AIC Canada

As a way to check on the roads as the season progresses, the team uses ground-penetrating radar (GPR) from EBA's geophysics division to check the thickness of the ice and identify shallow water shoals in addition to manual ice measurements. The radars are placed in a sled and attached to the back of a van for dragging along the ice, and information is fed back to computers in the van.

"It is just not feasible any more to cut into the ice," points out Mr Proskin. "GPR is becoming the standard method for measurement. When interpreted by a geophysicist, it can reveal additional

information about the ice that we may not have had before."

Pipeline in the sea

In Alaska, Alaska Interstate Construction's (AIC) Fred Hargrave works with a different terrain from his counterparts in the Canadian Northwest Territories.

Unlike the availability of snow in the Canadian north, Mr Hargrave says the desert-like conditions found on the frozen waters around northern Alaska mean that his company often uses ice aggregated into 10cm chips, which is mined from lakes with trimmers, and mixed with water to build ice roads.

Mr Hargrave says the advantage of this method is that it allows ice roads to be built up faster than with a flood-pump and snow because the water-aggregate mix freezes on contact. This builds a much stronger road that will last longer and withstand heavy traffic.

Aside from its work in Alaska, AIC has also constructed floating and grounded ice roads, ice runways and ice drill pads in Russia, Kazakhstan and other locations across the world's northern regions.

One of the more complex ice projects undertaken in recent years involved the placing of a pipeline in the Caspian Sea, ►

"Desert-like conditions on the frozen waters around northern Alaska mean that AIC often uses ice aggregate"

► using a major ice road and amphibious excavation equipment, which was able to float. If a breakthrough were to occur, the equipment would reduce risks and protect the operators.

"Our idea was to go in the winter and freeze the ice right down to the ground, so they could dig a small trench and install the pipeline," explains Mr Hargrave. He adds that the method was more economical than alternative approaches.

The ice roads that AIC builds average 2.5-3m thick and platforms can reach up to 45m wide. The length and thickness of each ice structure is determined by the loads it will carry, the amount of time it is needed for and the kind of water it is built over.

For example, if the structure is in the Arctic Ocean or Beaufort Sea, the saltwater is very dense, whereas freshwater found inland is less dense and may be slightly warmer than the waters found closer to the North Pole.

Environmental concerns

The other major consideration for ice engineering in the north is the protection of the environment, including fragile tundra and permafrost layers.

In a time when the protection of ecosystems is becoming a more prominent concern, ice engineering allows companies to build roads that leave the area unspoiled when they melt in the 'off seasons'.

For Mr Hargrave's team, using the ice aggregate to create almost instantaneous roadways leaves the tundra underneath untouched. "You're not hitting the tundra and the virgin ground (using ice aggregate)," he points out. "You're protecting the environment."

Although Mr Hayley can recall the days when little environmental regulation was applied to the Canadian ice-road industry, he comments that it is now a guiding force behind everyone who works on such roads.

"The permitting process and regulations have become substantially greater than they used to be, which is good because it makes the companies work in a responsible way," he adds.

"If we do it wrong, we could cause enormous damage." ▼

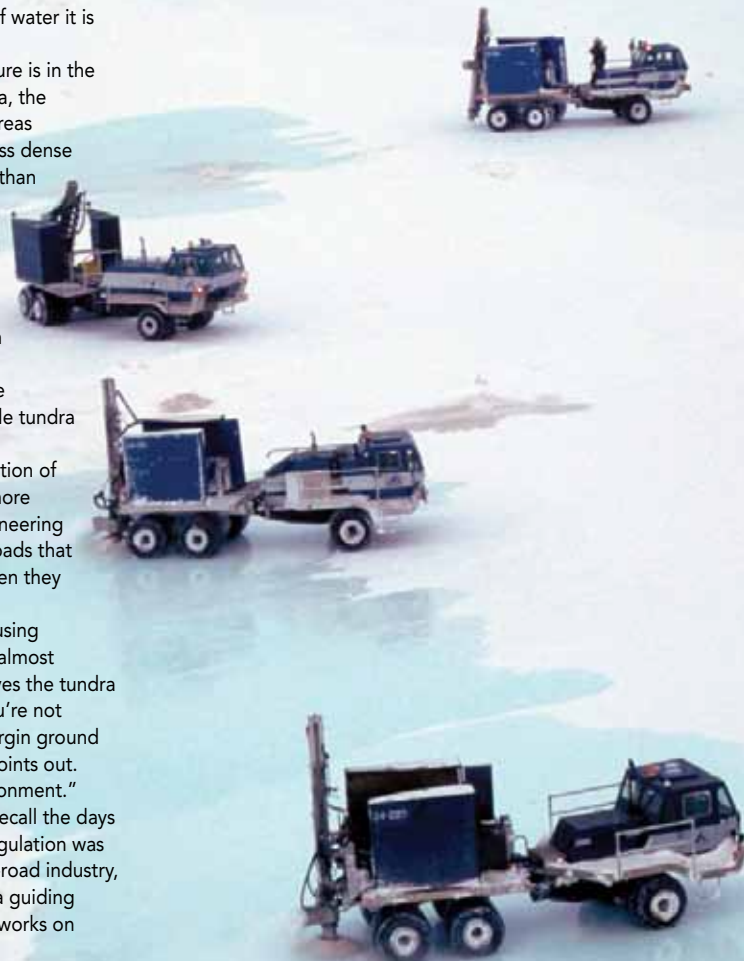
For information, see www.tetrattech.com



Cracks in the TCWR ice road found during an inspection

Photo courtesy of Sam Proskin

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Trucks work to harvest ice aggregate from a river during the ice construction season

Photo: AIC Canada