Ice Bridging in Alaska: Arctic Engineering at Its Finest

By First Lieutenant Collin W. Russell and Lieutenant Colonel Marc F. Hoffmeister

An ice bridge is a frozen, man-made structure on the surface of a bay, river, lake, or sea. Exploiting the natural conditions found in an arctic environment, ice bridges provide access to remote areas that do not have permanent road networks. If constructed properly, the bridges can facilitate the efficient transportation of equipment and personnel to otherwise inaccessible areas, saving time and money.

Few Army engineers have the opportunity to train on a rare skill set—ice bridging in an arctic environment. The 6th Engineer Battalion (Combat) (Airborne) was uniquely positioned for this opportunity, which provided valuable training for the unit's Soldiers and practical benefits for U.S. Air Force engineers in Alaska. Throughout January and February 2011, a task-organized team of 35 Soldiers from the battalion constructed an ice bridge over the Delta River at the U.S. Army Cold Regions Test Center at Fort Greely, Alaska.

Ice Bridging: A Lost Art

Enabling mobility is nothing new for Army engineers, but the weather conditions necessary to sustain an ice bridge are so extreme that the skill set is difficult to train. An analysis of potential contingency missions in cold-weather environments reveals a need for ice bridging as a capability within the force. Across the Army, there is a lack of existing doctrinal processes in ice bridging and arctic engineering in general. The 6th Engineer Battalion (Combat) (Airborne) recognized this deficiency and has made a concerted effort to institutionalize ice bridging as a capability.

Ice Bridging Test Bed

Due to its location in Alaska and its close working relationship with the Cold Regions Test Center, the 6th Engineer Battalion (Combat) (Airborne) is well suited to serve as the Army's subject matter expert in constructing ice bridges. According to U.S. Army Alaska policies, the battalion trains its Soldiers on cold-weather survival skills in courses taught at the unit level or at the U.S. Army Northern Warfare Training Center in Fort Wainwright, Alaska. This essential training equips Soldiers with the individual skills required to operate in an arctic environment. The battalion also partners with the Cold Regions Test Center, providing operators to conduct cold-weather testing of engineer equipment and variants of the mine-resistant, ambush-protected vehicle.

Equipped with the skills to survive and operate in an arctic environment, the battalion undertakes an annual mission to construct an ice bridge across the Delta River or the Tanana River. The lack of any bridge crossing on these rivers makes ice bridging essential for the Air Force to conduct maintenance and construction on the Oklahoma Bombing Range and Blair Lakes Impact Area on the far side of both rivers.

The ice bridge constructed in February 2011 was 1.2 miles across the Delta River and 75 to 100 meters wide. The battalion team pumped about 3 million gallons of water during the mission. The bridge was strong enough to allow for the transport of excavators weighing 165,000 pounds. As a direct result of these efforts, the Air Force 354th Civil Engineering Squadron (Range Maintenance) was able to—

- Grade and groom 26 miles of winter trail.
- Remove 12 destroyed target vehicles and 51 destroyed container express boxes.
- Construct four new hangar targets and a new fuel farm.
- Build 60 new Maverick tank targets and repair six damaged tank targets.
- Fabricate three MiG-29 and 19 antiaircraft artillery targets.
- Excavate and move 74,335 cubic yards of fill material while constructing—
  - Four new antiaircraft artillery pads.
  - 12 new hangar target pads.
  - Six miles of new roads.
- Remove 408,000 pounds of metal target residue.
- Transport and use 26,975 gallons of diesel fuel.

Challenges of Ice Bridging

Operating in a cold-weather environment presents unique challenges. The severe cold and gale force winds during Alaska's winter present some of the world's toughest construction conditions. Extreme cold weather can cause equipment malfunctions that are not normally present in warmer climates. Hoses can freeze and become stuck, various items can shatter if dropped, and vehicle brakes can freeze and become inoperable, among other challenges. These malfunctions can prolong construction timelines or endanger an entire mission. Using a small-unit support vehicle equipped with an arctic heater in the rear passenger cab or a warming shelter to keep idle equipment from freezing prevents malfunctions and saves the time it would take to bring equipment to operable temperatures. Routine maintenance is especially critical when operating in severe cold weather.

Safety is another consideration. Soldiers on this mission endured the harshest conditions imaginable, with significant risk of cold-weather injuries. After getting wet while pouring 100,000 gallons of water in temperatures of -26°F, one Soldier remarked that he felt like a "human popsicle," a condition experienced daily by all of the Soldiers during the mission. The Army's extended cold-weather clothing system was not adequate for the subzero temperatures encountered, so Soldiers combined standard Army-issued undergarments with commercial off-the-shelf outerwear. Special waterproof, breathable gloves were locally purchased to ensure dexterity while working with the moving parts on various pieces of equipment.

Types of Ice Bridges

There are three types of ice bridges constructed in the arctic environment:

- Open water bridge.
- Suspended water bridge.
- Grounded ice bridge.

A Soldier monitors a pumping station to ensure that the intake valve does not freeze shut.

A container express is dragged into position to be used as a target on the Oklahoma Bombing Range.

A Soldier drives a four-wheeler with an attached snowplow to contruct an initial berm for the ice bridge. Two Soldiers in the foreground break up the rough surface with hand-tools.

According to Field Manual (FM) 3-34.343, *Military Nonstandard Fixed Bridging,* "Engineers [can] create ice bridges by floating large sections of ice cut from the rear of the ice pack into a transverse position across the water gap. Ice bridges are only an expedient temporary measure."

The suspended water bridge is constructed when the intended gap crossing intersects a flowing river or a lake that has ice already established on it. The water under this type of bridge can degrade the thickness of the ice from the bottom upward, thus requiring constant monitoring of the ice. The grounded ice bridge constructed by the 6th Engineer Battalion (Combat) (Airborne) was a structure that closely resembled a road rather than a bridge. A grounded ice bridge is suspended over water in some areas, while grounded on top of a sand berm or dry portion of the river in other areas. A bridge of this type is usually constructed to cross large expanses of land.

Four-Phase Construction Model

Construction of an ice bridge is a four-phase operation. The first three phases are berming, shaping, and pumping. After the bridge is constructed, the

maintenance phase begins, sustaining the trafficability of the bridge to allow continued mobility along the lines of communication. Ice bridge construction does not follow a set doctrine, so the team developed its own standards and procedures to follow. The key to success lies in understanding the variables that are present: temperature fluctuations, water availability, terrain layout, and the amount and weight of the equipment needed to cross the gap. Only when these variables are understood and analyzed can the gap crossing be constructed.

The common equipment used included M1088 tractor trucks; high-mobility, multipurpose, wheeled vehicles; shovels; mattocks; propane torches; and marking equipment. The mission-specific equipment included typhoon and general-purpose pumps, 3-inch rubber hoses, small-unit support vehicles, 5,000-gallon water trailers, and ice augers. All equipment had to be outfitted for cold weather by ensuring that appropriate fluids and engine block heaters were used.

Phase I—Berming. The berming phase consists of snow-moving operations to create a barrier to stop overflow, which occurs when water below is under pressure, rupturing the ice and covering the surface with shallow water. The shallow water freezes inconsistently and creates a less stable ice structure. The ice below the surface must be at least 36 inches thick for suspended ice or 12 inches thick for grounded ice. These thicknesses will hold the weight of a single D7 bulldozer and represent the minimal thickness to proceed with ice bridging operations using heavy equipment.

Phase II—Shaping. The shaping phase aims to create an even distribution of water during the third phase. During the shaping phase, Soldiers hastily fill existing ravines, gullies, or crevices with snow, ice, or dirt. Water is then added and allowed to freeze overnight. This process decreases the natural variations in the terrain by filling the low areas with "icecrete," which is frozen water mixed with dirt, sand, or gravel. It can be worked in the same way as concrete, making solid fills that can then be expanded upon in the next phase.

Phase III—Pumping. The pumping phase creates a uniformly smooth surface that will ultimately become the surface of the ice bridge. The goal is to create a consistent level of ice across the entire span of the ice bridge by pumping water from the river directly below or from a 5,000-gallon water trailer. This phase relies heavily upon layering ice at appropriate intervals to create strength and density so that it can support the weights that will cross the bridge. The battalion team used a 4.5-horsepower, 3-inch pump to pull water from the river and a water trailer.

Phase IV—Maintaining. The maintenance phase involves monitoring the thickness of ice down the length of the bridge and ensuring that the ice does not degrade. To maintain the strength and thickness of the ice, a minimum of 1 inch of ice should be spread daily across the length of the bridge. The ice bridge can be degraded by wind damage from the top down or by the flow of the river current below.

Institutionalization of Ice Bridging Capabilities

Due to the lack of existing doctrinal processes, the 6th Engineer Battalion (Combat) (Airborne) has several ongoing initiatives to institutionalize ice bridging across the force. Based on lessons learned from the ice bridging mission in January and February 2011, the battalion developed standing operating procedures that documented best practices and lessons learned. The success of the ice bridging mission has resulted in a greater understanding between Army and Air Force engineers. The deputy chief of staff–engineer of U.S. Army Pacific is assessing the feasibility of conducting a subject matter expert exchange program in which theater security cooperation objectives can be met by engaging partner nations on technical engineering topics. Ice bridging is a capability that could benefit a number of countries within the U.S. Pacific Command area of responsibility. If the program is approved, the battalion's expertise could be shared with friends and allies, supporting theater security cooperation objectives and further cementing ice bridging as a niche capability with utility far beyond Alaska.

Within months of completing the ice bridge across the Delta River, the battalion initiated planning for ice bridging operations during the winter of 2011–2012. Lessons learned will be applied to those operations in order to refine the tactics, techniques, and procedures to enable mobility across what would otherwise be severely restricted, or even impassable, terrain. As these tactics, techniques, and procedures are refined, the battalion will disseminate best practices and continue to take the lead in arctic engineering, providing a niche capability to an Army that may one day require mobility support during contingency operations in an arctic environment.

For more information concerning ice bridges, contact First Lieutenant Collin Russell at <*collin.russell@us.army.mil*>.

Reference:

FM 3-34.342, *Military Nonstandard Fixed Bridging*, 12 February 2002.

First Lieutenant Russell is a platoon leader for the 56th Engineer Company, 6th Engineer Battalion (Combat) (Airborne) at Joint Base Elmendorf-Richardson, Alaska. He served as the officer in charge of the team that constructed an ice bridge over the Delta River in February 2011. He is a graduate of the Engineer Basic Officer Leadership Course and holds a bachelor's degree in history from Texas A&M University.

Lieutenant Colonel Hoffmeister is the commander of the 6th Engineer Battalion (Combat) (Airborne). He holds a bachelor's degree in aerospace engineering from the U.S. Military Academy, a master's degree in engineering management from the University of Missouri–Rolla (now Missouri University of Science and Technology), and is a registered civil professional engineer. He is also a graduate of the Army Command and General Staff College, the Joint Combined Warfare School, and the Engineer Officer Basic and Advanced Courses.