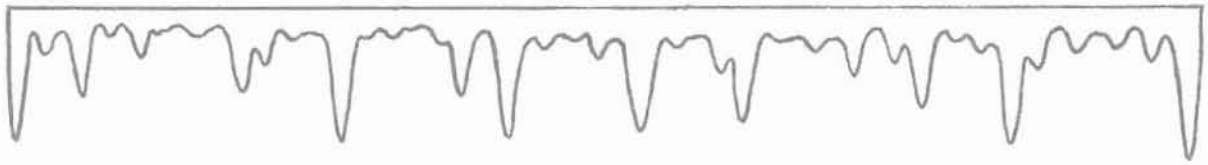
THE COLD, HARD FACTS ON CLASSIFYING ICE



By Captain Chris Sultemeier

As any military leader will tell you, time can be your best friend—or your worst enemy.

In an age of increasingly advanced and mobile military vehicles, the pace of any future conventional war will likely be fast and furious. Units halted by natural obstacles—not to mention those placed by the enemy—will become quick target opportunities.

The European theater has been the winter graveyard of many an otherwise capable army. It would provide perhaps the likeliest location for cold weather combat in any future conflict that may involve the U.S. Army. And for the inevitable cold weather river crossing operations, it would pose an uncommon challenge for field commanders.

While all maneuver and combat support commanders are familiar with standard bridging operations, few have experience or training in ice bridging.

A similar lack of experience with ice bridging may have foretold the winter disasters that lay ahead of the German Army as it pursued the retreating Russians in the early days of World War II. Generaloberst Halder, Chief of the German Army General Staff, wrote:

"The supply and railway situation east of the Dnieper was extremely critical during the winter of 1941-1942, since the withdrawing Russian troops had destroyed all bridges across the river. At that time, only makeshift bridges could be constructed, because many months would be required to build bridges strong enough to resist the pressure of high water....In order to obtain a railway bridge in the brief time available, it was decided to build an ice bridge....The complete lack of any experience on the part of all competent German agencies was a characteristic of its construction."

While the German railway ice bridge over the Dnieper was completed in only 12 days, it took three weeks of computations and planning before construction actually began. Because the Germans had little knowledge and no experience of ice bridging operations, they lost precious time—and suffered an unnecessary delay in their bid to destroy the retreating Russians.

In today's U.S. Army, we face a similar lack of training. With the exception of the 6th Infantry Division (Light) in Alaska, the Army has negligible ice bridging training or experience.

And as our mechanized forces get faster, the vehicles are getting heavier. In a cold weather environment, ice bridging is a very real possibility for both forward combat units and the support trains. Because of this, every engineer officer and NCO should have a working knowledge of determining the capacity of ice to support river crossing operations.

Perhaps the most difficult question faced by engineers in determining the feasibility of ice bridging is how to determine whether the ice at a potential river crossing site is strong enough to support the expected vehicle traffic. Many competing factors, including temperature, velocity of the underlying stream, foreign matter and air voids in the ice, have a direct impact on the strength of the supporting ice.

Fortunately, there has been some research—both scientific and through the "school of hard knocks"—and formulas for computing the load-bearing capacity of ice are available.

For crossings where the temperature has been consistently below -l0 degrees Celsius (14 degrees Fahrenheit), the Cold Regions Research and Engineering Laboratory (CRREL) formula should be used as the engineer's standard computation method:

$$h = 11\sqrt{P_t}$$

$$h = 12\sqrt{P_w}$$

h = thickness of ice in centimeters

P_t = weight of track vehicles in tons (2000 lbs)

P_w = weight of wheeled vehicles in tons (2000 lbs)

Other formulas have also been used for this extreme cold weather condition. During their construction of the Dnieper River ice bridge, the Germans developed their own capacity/design equation:

$$h = 13\sqrt{P}$$

Current Soviet doctrine uses the following equations for ice bridging:

$$h = 10\sqrt{P_t}$$

$$h = 12\sqrt{P_w}$$

h = thickness of ice in centimeters

P_t = weight of track vehicles in tons (2000 lbs)

P_w = weight of wheeled vehicles in tons (2000 lbs)

An engineer officer at the U.S. Army Engineer School, CPT James Langan, used the Plate Theory approach to develop an independent equation. The results of his analysis were very similar to the formulas already in use, and thus reinforce current doctrine:

$$h = 7\sqrt{P_t}$$

$$h = 8.3\sqrt{P_w}$$

All of these equations apply to ideal conditions where there is no debris or large air pockets in the ice, and the temperature has remained below -10 Celsius for a long period of time (10 to 14 days). Often these conditions are not present and reduction factors must be applied to determine the capacity of the ice.

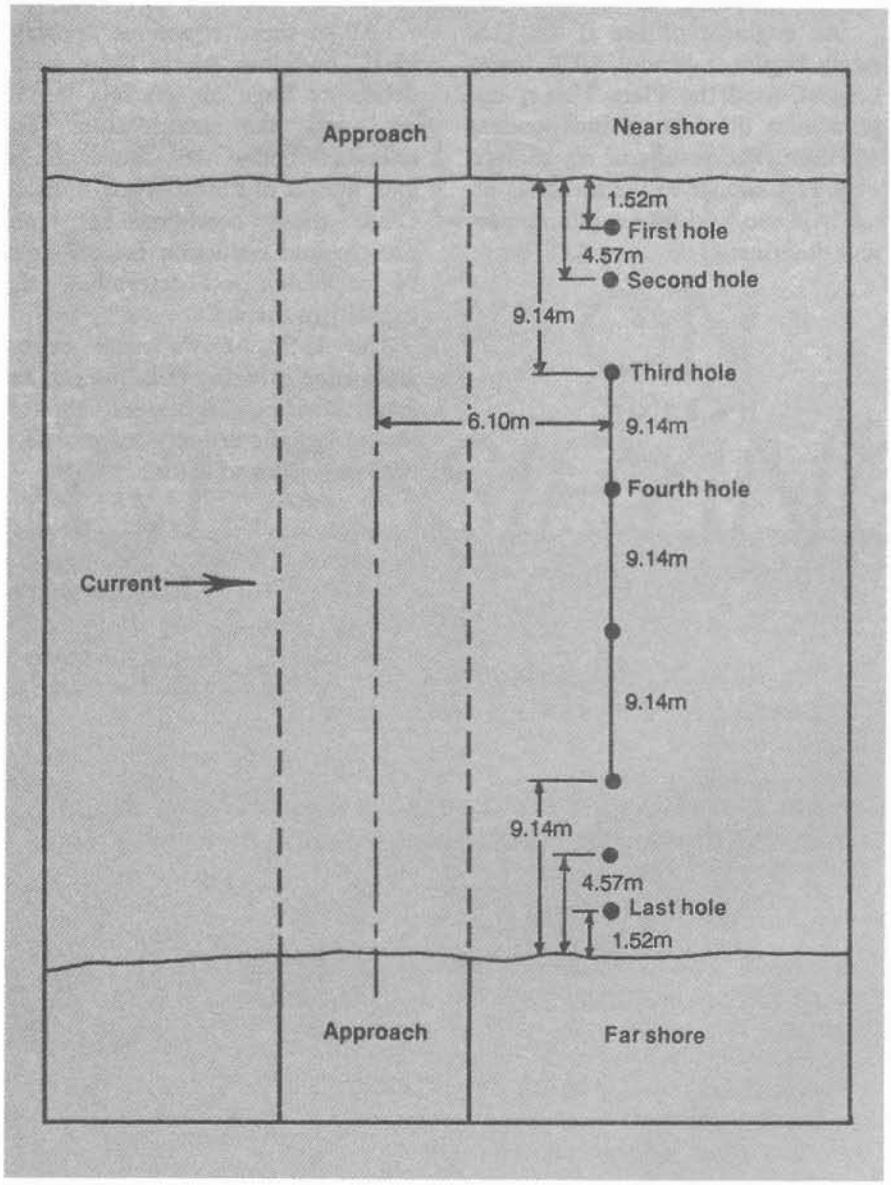
The U.S. Army's most experienced ice bridging unit, the 6th Infantry Division (Light), uses the following specific reduction factors for both strength and color.

Strength factor

- Ice is solid, temperatures have remained at or below freezing for the previous week; s = 1.0
- Ice is solid, temperatures have been above freezing during the day, but drop below freezing during the night; s = 0.9
- Ice is solid, water is running on the ice surface from runoff or overflow; s = 0.7
- Ice is not solid, water or airpockets are found between layers of ice; s = 0.7
- There is an air pocket under the ice, so the ice is not floating on the water underneath; s = 0.6

Color factor

- Ice is clear (transparent or black color); c = 1.0
- Ice is semi-clear (contains both transparent black and white layers of ice; c = 0.9
- Ice is white (snow mixed with ice); c = 0.8
- Ice is discolored (stained brown or yellow); c = 0.7



You are the platoon leader/task force engineer in a combat engineer battalion. An armor battalion commander has requested that you determine the feasibility of crossing a nearby river. The heaviest vehicles within the maneuver battalion are M1 *tanks. From your reconnaissance, you determine that the ice is white and appears to be solid. The temperature has been above freezing during the day. How thick must the ice be to support the maneuver battalion's crossing?*

From FM 5-36, *Route Reconnaissance and Classification*, an M1 tank weighs 60 tons.

Because of the color of the ice and the varying temperature conditions, the reduction factor formula from the 6th Infantry Division (Light) provides the most reliable answer:

$$h = \frac{11.3\sqrt{P_t}}{(c)\ (s)}$$

$$h = \frac{11.3\sqrt{60}}{(0.8)\ (0.9)}$$

$$h = 121.6 \text{ cm}$$

$$h = 47.5 \text{ inches}$$

The 6th then applies these factors to their capacity equation, which is very similar to the ones already discussed:

$$h = \frac{11.3\sqrt{P_t}}{(c)\ (s)}$$

$$h = \frac{12.7\sqrt{P_w}}{(c)\ (s)}$$

c = color factor

s = strength factor

Because all equations begin with ice thickness, the above chart shows the locations for measurement. It is important that the proposed centerline be no closer than 100 meters from the edge of open water. Open water is defined as the location where the ice is 50 percent as thick as the ice near the centerline.

We must increase safety margins if a high volume of traffic is expected. Also, vehicle spacing must be no less than 100 times the thickness of the ice.

Let's take a hypothetical situation as an example of how to apply one of these formulas:

Commanders and S-3s should include simulated ice classification exercises when planning field training—even during the hottest weather. While most units may not have the opportunity to conduct such training under realistic cold weather conditions, all engineer leaders should practice the application of these ice classification formulas.

Because on the modern battlefield, if you do not know how to ensure a safe ice crossing for maneuver elements, time may be your worst enemy.



Photo by Steve Miller

(Above) Armored personnel carriers from the 172nd Infantry Brigade prepare to cross an ice bridge over Alaska's Tanana River during Exercise Brim Frost. (Below) Soldiers from the 47th Enginer Company work on a water pump being used in an ice bridging operation.



Photo by Scott West

Suggested Readings:

1. *"CCREL Notes for the Winter Battlefield,"* U.S. Army Corps of Engineers, Cold Regions Research and Engineer Laboratory, Hanover, New Hampshire, April 1985.

2. *"Ice Railway Bridge Over the Dnieper,"* Hauptman Ludwig Schmeller, Foreign Military Studies, F-3431, Historic Division, U.S. Army Europe, 1953.

3. *"Floating Bridges, Ferry and Ice Crossings,"* Telov and Kanokov, published by the Soviet Department of Transport, Moscow, translated by the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, Virginia, August 22, 1978.

4. *"Evaluation of Ice-Covered Water Crossings,"* Arnold M. Dean, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, June 1980.

5. *"Ice Bridging: The Plate Theory Approach,"* Captain James E. Langan, U.S. Army Engineer School, Ft. Belvoir, Virginia, January 20, 1987.

6. *"River Crossings, Soviet Style,"* Lieutenant Colonel William P. Baxter (Retired), ARMY, July 1980, pp 39-41.

7. *"Squad Leaders Guide for the Construction of Ice Bridges,"* 172nd Infantry Brigade, PAM 350-11, Headquarters, 172nd Infantry Brigade, Ft. Richardson, Alaska, November 8, 1985.

Captain Sultemeier most recently served as the Non-Standard Bridging Instructor for the Engineer Officer Advanced Course at Fort Belvoir. Previously he served in engineer assignments with the 1st Infantry Division at Fort Riley. He received a B.S. degree from the United States Military Academy.